Level 3 Physics 2013
Study Booklet of Madness

2013 L3 PHY EXAM: starts at 2:00pm
Monday the 25th of November

To prepare yourself for the NCEA externals you should be comfortable with the following:

- **Vocabulary** (terms, definitions, symbols and units)
- **Equations**
  (even though you DON'T have to memorize them, know what types of problems go with certain ones!)
- The EXACT **language of the NCEA standard** – to know what you may be examined on
  – and what's NOT on the exam!
- The **National External Exams and Sample Questions**

AND time-management skills

– know that you only have 3 hours to work on 3booklets

6 credit Mechanics ≈ 60 minutes,

6 credit Electromagnetism ≈ 60 minutes,

4 credit Waves ≈ 50 minutes,

- Have a Plan!
- Which booklet are you going to do first (your strongest topic)?
- Which booklet are you going to leave to do last (your weakest topic)?

3 - Step Method to Survive Revision:

Step 1: Review what you know and list what you don't know

Step 2: Focus on what you don't know
(use whatever you have to learn it)

Step 3: Repeat steps 1 and 2

Level 3 Physics 2013 Study Booklet Table of Contents:

You should also receive an answer booklet with:
- Answers to both matching exercises (vocabulary and equations), descriptions of diagrams in review sheets and answers to question sets.

The look and marking of your exams:

You should understand how your exams will look and be marked.
It is essential that you attempt to answer each and every question's part.
If you realize that you're running short of time the knowledge of how your exam is marked may influence how you target your remaining time.

The look of your physics exams:

- Each of your 3 exams will have 3 or 4 large questions, each with 3 to 5 parts (a, b, c, d…) in 8 to 12 pages.
- At least 1 of these parts will have an answer up to excellence-level (usually 2). Many times there will be 1 mathematical E-level part and 1 descriptive or paragraph E-level part.
- To get excellence you usually will have to overtly link your descriptive answer to the context of the question, instead of just regurgitating theory. (See the section on page 6 for more info on this).
- Sometimes an E-level or M-level question will have bullet-points to help guide your answer. Attempting even 1 or 2 of these bullet points should get you some marks even if you cannot fully answer the question.

The marking of your exams:

- Physics exams, like all of your externals in any subject, will be marked with the 8-point system to make a "total score" that will then be turned into your final mark: N, A, M or E.
- To get this each question will get 0 to 8 points based on all of your answers in that single question: N_0, N_1, N_2, A_3, A_4, M_5, M_6, E_7 and E_8.
- Your total will be added:

  For a 3 question test (max of 24 points) the A, M, E **minimum** thresholds:
  - A = ¼ x 24 + 1 = 7
  - M = ½ x 24 + 1 = 13
  - E = ¾ x 24 + 1 = 17

  For a 4 question test (max of 32 points) the A, M, E **minimum** thresholds:
  - A = ¼ x 32 + 1 = 9
  - M = ½ x 32 + 1 = 17
  - E = ¾ x 32 + 1 = 25

WARNING: these are the minimum thresholds. The chief marker of each exam can adjust them upwards by 1 or 2 depending on the easiness or difficulty of the exam after you've taken the test. Each test's thresholds will be posted in the NCEA exam website by the time you get your exams back in January.

The marking of a single question:

- Most physics exam questions will have 3 or 4 parts (a, b, c, d) instead of a single long essay like biology.
- The usual minimum to get A_3 will be to get *2 parts correct at some level*. But if the question has 4 or 5 (or more) parts you may need to get *more than half parts correct* at some level to get A_3.
- If you only answer 1 or 2 parts of an entire question correct at some level you may only get N_1 or N_2, depending on how many parts the question has.
- Similarly, to get M_5 you will usually need to get *half* (or 1 more than half) of the possible M-level answers.
- And to get the elusive E_7 you will need at least 1 of the E-level answers. To get E_8 you will need either 2 E-level answers or a complete single answer if only 1 part leads to excellence.
- We have been told that your exam will be marked from "top down". This means the marker will look to see if you get E_8 or E_7 before working out if you get M_5 or M_6… and then finally look for evidence of A_3 or A_4 before N_2, N_1 or N_0.
- **WARNING:** This "top down" marking approach ***DOES NOT*** mean that you should only answer the E-level parts. ***You should try to answer each and every part of every question***. Answering even 1 or 2 parts of a tough question may give you the needed 1 or 2 points to pull you over the A or M threshold.

Techniques on Significant Figures (and units):

As you probably know, AT LEAST ONCE on each of the 4 exams you will be asked to round your answer to the proper significant figures or give proper units. Remember to round off to the **SMALLEST** number of significant figures used in your calculation.

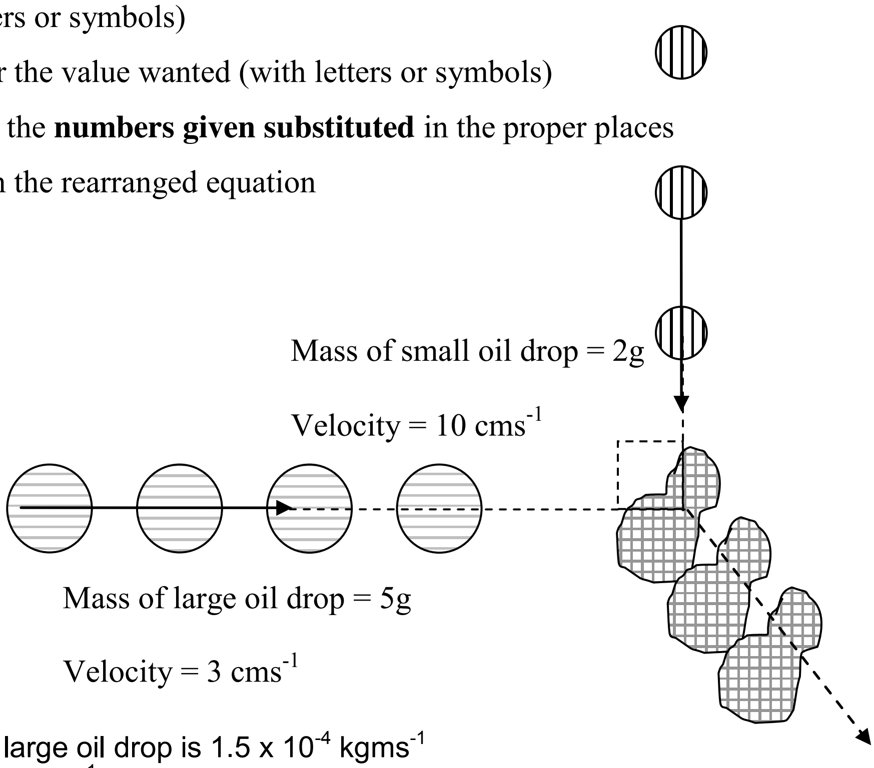
Techniques on "SHOW" Questions:

"Show" questions give you the answer – you must show ALL steps (including rounding) that give that answer. Most of these are "achievement" level but they can be higher.
The FIVE minimum steps:

1. Write the **equation** used (with letters or symbols)
2. Write the **rearranged equation** for the value wanted (with letters or symbols)
3. Write the rearranged equation with the **numbers given substituted** in the proper places
4. Write the **unrounded answer** from the rearranged equation
5. Write the **rounded answer**

EXAMPLE 1:

Stuart watched a video that showed two streams of oil drops colliding at right angles and sticking together. This is represented in the diagram. After sticking together the combined oil drop moved off in the direction shown.

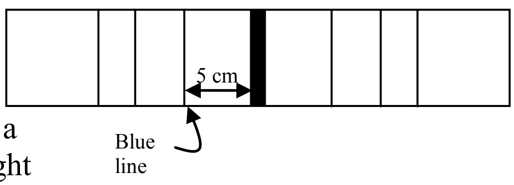


(e) Show that the momentum of the large oil drop is 1.5×10^{-4} kgms^{-1} and of the small one is 2.0×10^{-4} kgms^{-1}.

ANSWER 1:

ρ_{large} = mv = 0.005 kg x 003 ms^{-1} = 15 x 10^{-5} kgms^{-1} = **1.5 x 10^{-4} kgms^{-1}**
ρ_{small} = mv = 0.002 kg x 010 ms^{-1} = 20 x 10^{-5} kgms^{-1} = **2.0 x 10^{-4} kgms^{-1}**

EXAMPLE 2:



Stuart's father is an astronomer and uses a diffraction grating to analyse the light coming from stars. He looks at one star and records a pattern similar to the one shown below. He knows he is looking at light from a blue coloured star and that the first line is the dominant blue one. If the diffraction grating he uses has 1,000 lines per mm and the grating is 10 cm from the screen he sees the pattern on, **show** that the wavelength of the first order blue line he sees is 5.00×10^{-7} m.

ANSWER 2:

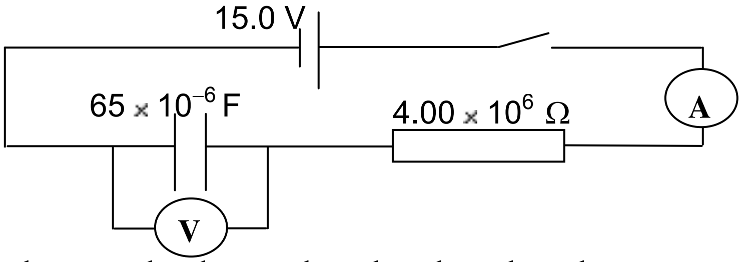
$n\lambda = \frac{dx}{L}$ with n = 1 gives $\lambda = \frac{dx}{L}$ that gives $\frac{1\times10^{-6}\times5\times10^{-2}}{0.1}$ = $\lambda = 5\times10^{-7}m$

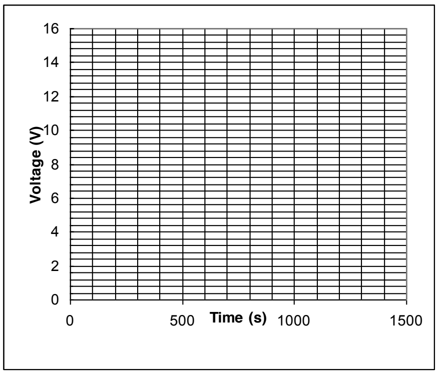
Techniques on Graphs:

- When a question asks for a "sketch" of a graph the minimum mark usually requires the correct **SHAPE**.
- **Label** both axis (if they have not done that for you) with symbols and units
- If you can find or calculate or know the **number values** for the axis – PUT THEM ON YOUR GRAPH!

EXAMPLE 1:

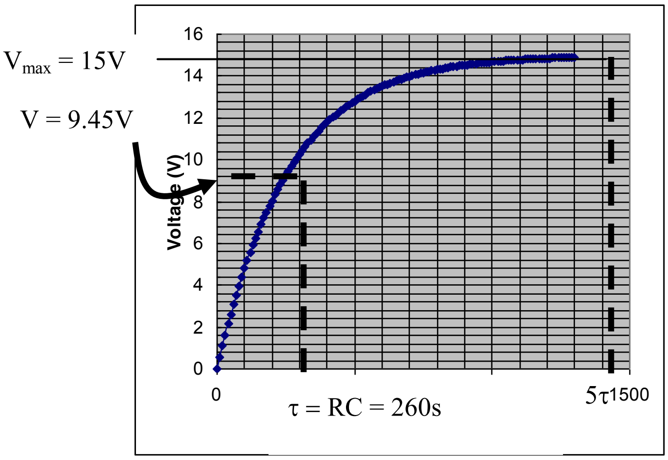
In their investigation of the capacitor, Stuart and Julia connected it into a circuit as shown. When they closed the switch they noticed that the readings on the ammeter and voltmeter changed in a steady and smooth fashion.





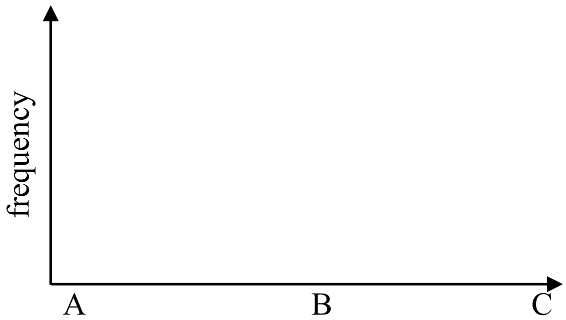
On the axes, sketch a graph to show how the voltage across the capacitor plates changed once the switch was closed. Include at least one specific voltage value reached and the time at which it was reached.

ANSWER 1:

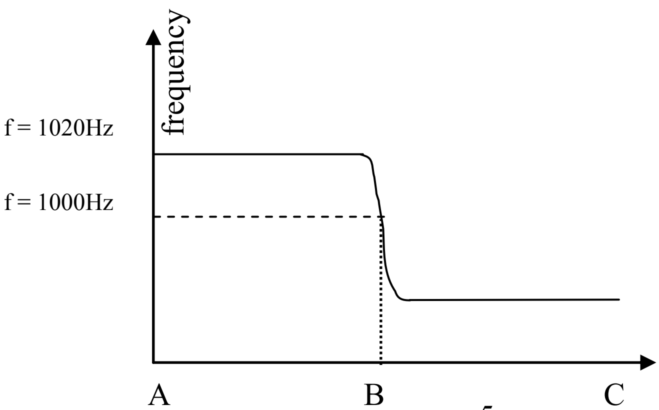


EXAMPLE 2:

Doppler – with object approaching: Sketch a graph on the axes to show how the frequency of the sound heard by a person walking from A to B to C would vary.



ANSWER 2:



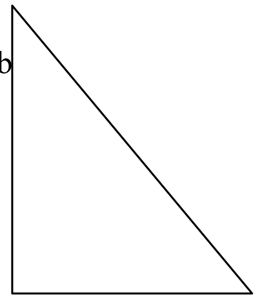
Techniques on Vector Diagrams:

For force, momentum, phasor or other vector diagrams make sure you:

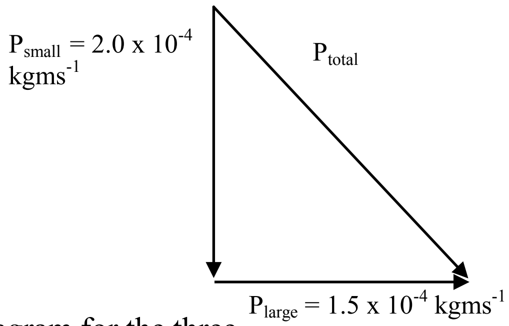
- Label each arrow with its **symbol or name**
- Draw the length of each arrow in **relative size** to the others
- If you know the angles – draw the arrows with proper **estimated directions**
- If you know the magnitude (size) or can calculate it – include the **number (with units)**

EXAMPLE 1:

Continued from the momentum droplet example ABOVE: His teacher drew a triangle to represent the vector diagram of the situation. Put arrow directions and lab on the vectors appropriate for this situation.

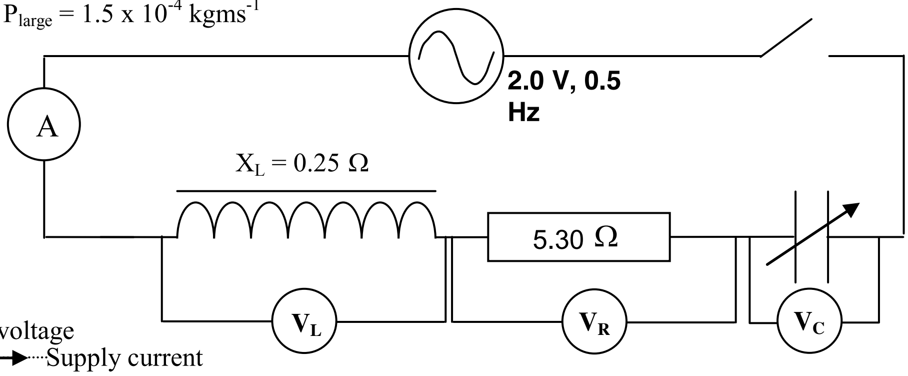


ANSWER 1:

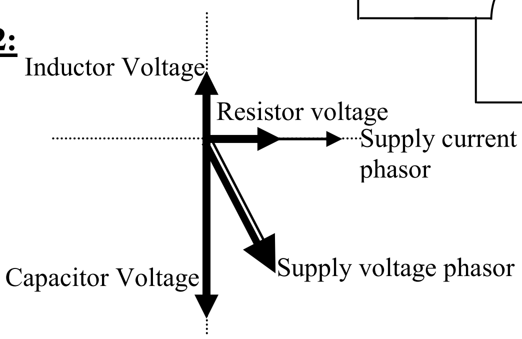


EXAMPLE 2:

Draw a phasor diagram for the three voltages of the components and the voltage of the source. Include an additional phasor for the current.



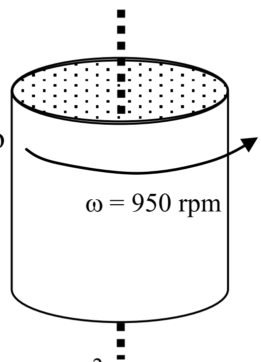
ANSWER 2:



Techniques on Estimate Questions

Very rarely, the exam will ask you to "estimate" or "use reasonable estimates" to find or calculate a value. The values the marker will expect depend on the situation – so have some idea of general values of mass, time, length, force, momentum, inertia, etc.

EXAMPLE: After Stuart's figure skating, his mother washes his skating costume in the automatic washing machine. The washing machine is essentially a vertical cylinder that spins on its vertical axis (see diagram) to a high velocity and uses the centrifugal effect to remove water from the washing. A typical machine drum spins to a rate of 950 rpm (revs per minute) from an initial zero speed.



QUESTION: The drum takes 5s to reach this speed. Using sensible estimates of drum mass and radius, determine the net Torque needed by the washing machine motor to do this. (Assume $I = mr^2$)

ANSWER: Estmate drum mass as 2kg, drum radius as 0.4m. Use $I = mr^2 = 2 \times 0.16 = 0.32 \text{kgm}^2$.

$\alpha = \Delta\omega \div \Delta t = 99.5 \text{ rad s}^{-1} \div 5\text{s} = 19.9\text{r s}^{-2}$ Hence $\tau = I\,\alpha = 0.32\text{kgm}^2 \times 19.9\text{r c} = \mathbf{6.4 \text{ kg m}^2\text{s}^{-2}}$

Techniques on Explanation Questions

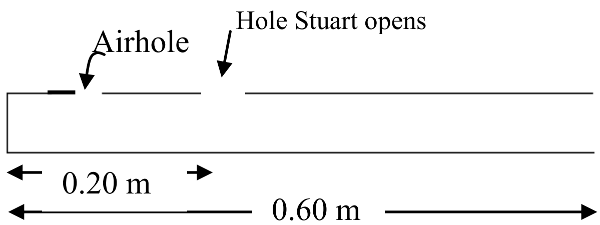
1. Identify **Key Words** and/or possible principles (eg cons of mom, energy, force)
   - if you answer the question WITHOUT these key words you will NOT be given credit
   - even if you say something totally true!
2. Draw **picture**
   - especially if the exam paper gives you room or asks you to!!!
3. List **quantities** involved (eg, force, mass, angular speed etc)
   - if you know the amount or numbers, or can quickly calculate them, then DO IT and include them in your answer
4. Write **formula** and or **principle** into your explanation
5. Overtly **link your theory to the situation involved** (to get E)
6. "If, then, because" formats can come in handy
   - explain formula in words and exactly how the variables affect each other

Checks at end:

- No "I think"
  - this is considered "fluff" or "useless filler"
  - Physics teachers want you to get straight to the answer – no messing about!
- Have I waffled?
  - these may stop you from getting "excellence"
- No repetition
  - these may stop you from getting "excellence"
- No contradictions
  - these may delete any other "correct" information in your answer!!!
- Check that your answer **answers the question** and relates to the topic on exam.
- Have you mentioned how the **situation links to the physics theory**?

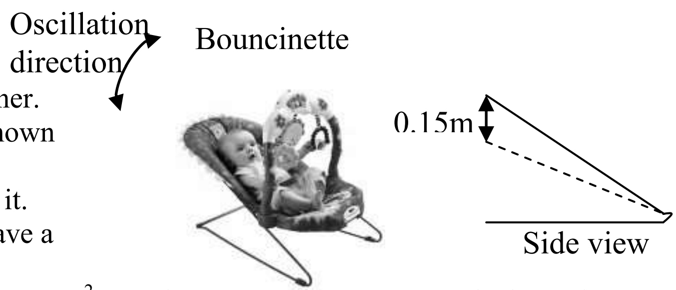
EXAMPLE 1:

When he opens a hole which is 20 cm from the closed end, Stuart can cause the next resonant frequency above the fundamental to sound when he blows. Explain why opening this hole allows the next resonant frequency to sound.



ANSWER 1:
A hole at 20 cm allows an **antinode** to exist at this point. This means that ¼ of a wavelength fits into 1/3 of a tube. As ¾ of a wavelength takes up 60cm, 1/3 of this must be at 20 cm. Thus the next resonant frequency is heard since the next standing wave is made (with its smaller wavelength).

EXAMPLE 2:



Julia has a baby brother whom she looks after for her mother. She put him in his bouncinette, (a bouncy lie-in seat) as shown in the photo. Julia notices that the high end of the bouncer deflects downwards by 0.15 m when the baby is placed in it. The bouncinette can be thought of as a spring, so it will have a spring constant which can be calculated.
Her Baby brother has a mass of 6.5 kg. Assume gravity = 9.8ms^{-2}. As the baby moves he causes the bouncinette to oscillate up and down. Over small angles the end of the bouncer appears to move in simple harmonic motion. Julia pushes the bouncinette down with the baby in it.

QUESTION: Explain, in terms of accelerations, what could happen to the baby if the bouncinette was pushed down further 17 cm and released.

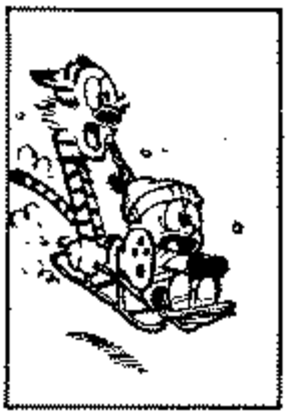
ANSWER 2:
When the bouncinette is depressed more than 17cm the net acceleration it applies to the baby exceeds that of 'g' (9.8). This will result in the baby still moving upward as it moves through an amplitude of + 15cm. If the baby is not well secured there is the potential for him to be **catapulted out of the bouncinette** and the baby will go into '**freefall**'.

AS 3.4 Part 1 – Translational Motion

Objectives

At the end of the unit students can:

	Calculate the centre of mass position using simple proportion and using the equation $m_1x = m_2(d - x)$
	Describe the motion of the centre of mass during a collision in terms of momentum conservation.
	Calculate the velocity of the centre of mass using the concept of (*total momentum*) / (*total mass*)
	Describe momentum in terms of Newton's second law.
	Describe impulse in terms of change in momentum.
	Analyse collisions in terms of conservation of momentum



AS 3.4 Part 2 – Rot. and Circ. Motion

Objectives

At the end of the unit students can:

Rotational Motion

	Convert between radians and revolutions.
	Use the basic formulae for ω, α, θ , and use the correct units.
	Use linear and rotational kinematic equations of motion.
	Convert between linear quantities land rotational quantities e.g. s , v , a , and θ , ω, α.
	Describe rotational motion in terms of an angular displacement/time graph, an angular velocity/time graph, an angular acceleration/time graph
	Read any of the graphs listed above in order to obtain a specified quantity or to describe the motion taking place.
	Use $\tau = Fr$ to measure torque.
	Describe the effect of a torque in terms of the angular acceleration produced.
	Use $\tau = I\alpha$ to analyse rotational motion.
	Explain the relationship between rotational inertia and (a) mass (b) mass distribution and shape
	Find angular momentum using $L = I\omega$ or $L = mvr$. (know when to use each formula)
	Understand the concept of conservation of momentum when there is no external torque and use this concept in rotational problems.
	Use $E_k = \frac{1}{2}I\omega^2$ (rotational kinetic energy)
	Use the idea of conservation of energy in rotational problems. (including rolling objects down a slope)

Forces

	Use vector diagrams where necessary to help solve various problems.
	Use free-body force diagrams to find the resultant force for an object.
	Use Newton's Law of Gravitation and the formula for centripetal force to describe the force on a satellite.
	Use Newton's Law of Gravitation with the formula for centripetal force to find the velocity or acceleration on a satellite. (Find the centripetal force or acceleration for any object moving in a circle)

AS 3.4 Part 3 – SHM

Student Learning Outcomes

At the end of the unit students can:

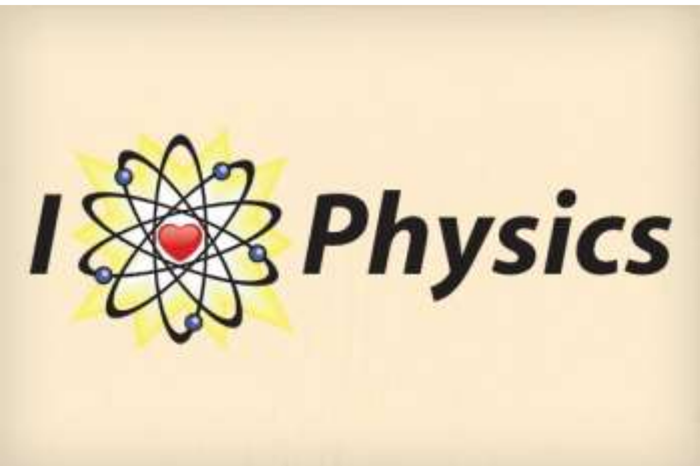
	Describe and find the frequency, period and angular frequency of S.H.M.
	Determine whether a motion is S.H.M. using $a = -\omega^2 y$.
	Describe conditions (features of) S.H.M. (in terms of acceleration or restoring force)
	Analyse S.H.M. using a reference circle. (timing can start in any position)
	Use phasors to draw a displacement/time, velocity/time or acceleration/time graph.
	Use a phasor diagram to represent the phase difference between displacement, velocity, and acceleration for a S.H.M.
	Describe where maximum values of quantities like displacement, velocity and acceleration occur in a S.H.M.
	Use the following formulae: $y = A\sin\omega t$, $v = A\omega\cos\omega t$ $a = -A\omega^2\sin\omega t$ and corresponding formulae if the displacement starts in a different position.
	Calculate maximum values of displacement, velocity, and acceleration using: $y_{max} = A$, $v_{max} = A\omega$, $a_{max} = A\omega^2$
	Understand and use the following terms correctly, restoring force, damping, natural frequency, forced oscillations & resonance
	Describe practical situations involving S.H.M. such as a spring, pendulum, tides etc.
	Use $T = 2\pi\sqrt{\frac{l}{g}}$ and $T = 2\pi\sqrt{\frac{m}{k}}$ correctly
	Use conservation of energy ideas to solve problems.

AS 3.6 Part 1 – D.C. Electricity

Student Learning Outcomes

At the end of the unit students can:

	Define a volt as work done on a charged particle moving in a uniform electric field
	Write down the factors that determine resistance (including drawing these relationships on graphs), explain what resistivity is, and use the resistance construction formula.(if time)
	Explain the difference between the EMF of a battery and its terminal potential.
	Include the internal resistance of the battery in any voltage or current calculations
	Use Kirchhoff's Laws to find voltages and currents in more complicated circuits.
	Describe the construction of basic capacitors using terms such as dielectric, non-polar, polar, electrolytic, variable, metal plates, electrolyte.
	Explain the basic function of a capacitor in a DC circuit and draw current/time graphs or voltage/time graphs for a capacitor as it is charging or discharging. Relate the time constant to these graphs and also calculate it.
	Use the basic capacitance definition in problems $C = \frac{Q}{V}$
	Find the total capacitance in series and parallel situations.
	Use the capacitor construction formula to calculate unknowns or to determine relationships (including drawing these relationships on a graph)
	Use $E_p = ½QV$ to calculate the energy stored in the electric field between the plates of a capacitor

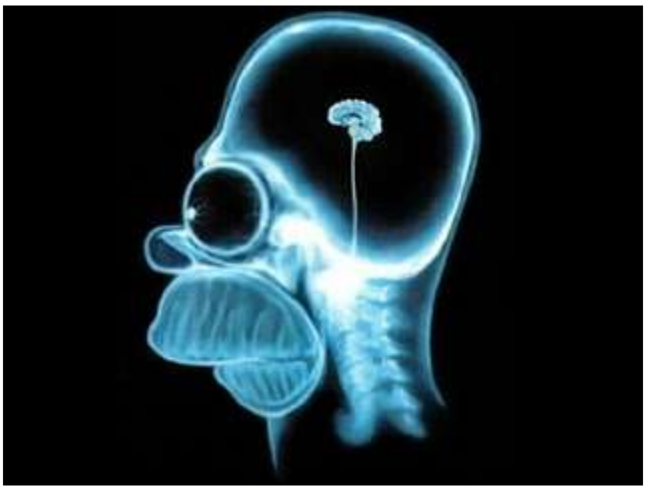


AS 3.6 Part 2 – Electromagnetism

Student Learning Outcomes

At the end of the unit students can:

	Use $\phi = BA$ to calculate magnetic flux
	Describe Faraday's Law in terms of a changing magnetic flux which creates an induced voltage.
	Use $\varepsilon = \frac{\Delta\phi}{\Delta t}$ to calculate induced voltage.
	Describe Lenz's Law in terms of an induced magnetic field which opposes change in the applied magnetic field.
	Use Lenz's Law to pred ct t e direction of an induced current caused by a changing magnetic flux.
	Calculate the induced voltage in a coil rotating with a constant angular velocity in a uniform magnetic field (know when maximum and minimum voltages occur)
	Explain the basic function of an inductor in a DC circuit and draw current/time or voltage/time graphs as current is building or dropping in a circuit.
	Relate the time constant to these graphs and calculate the time constant.
	Understand which factors affect the size and direction of the induced voltage across an inductor.
	Use the basic inductor definition in problems (including self inductance, mutual inductance and energy stored)
	Describe the operation of a transformer in terms of magnetic flux which is shared by a primary coil and a secondary coil.
	Understand the use of transformers in the transmission of electricity in NZ



AS 3.6 Part 3 – A.C. Electricity

Student Learning Outcomes

At the end of the unit students can:

	Define the relationship between rms power, rms voltage, rms current and their corresponding peak values
	Recall that the mains electricity supply in NZ has an rms voltage of 230-240V and a frequency of 50 Hz.
	Compare the energy dissipation in a resistor carrying direct current and alternating current; root-mean-square values
	Describe full wave rectification and smoothing in DC power supplies

Capacitors in AC

	Describe the different action of a capacitor in a DC and an AC circuit
	Define the reactance of the capacitor. (Also factors affecting reactance)
	Describe phase difference between AC voltage and AC current in a capacitor.
	Calculate the rms voltage and current in an AC capacitor circuit.

Inductors in AC

	Define the reactance of an inductor.(Also factors affecting reactance)
	Describe the phase difference between AC voltage and AC current in an inductor.
	Calculate the rms voltage and current in an AC induictor circuit.

RC and RL circuits

	Describe the phase difference between the capacitor voltage/inductor voltage and resistor voltage (and circuit current)
	Use a phasor diagram to calculate voltages.
	Calculate current.

LCR and resonance

	Describe the resonance of a tuned LCR circuit in terms of minimum reactance and maximum current. (relate to tuned radio)
	Use a phasor diagram to calculate voltages.
	Calculate the resonant frequency of a tuned circuit .(even when not given a formula !)
	Note the similarities between energy oscillations to an LCR circuit and SHM.

Impedance

	Calculate impedance in any of the above circuits.

AS 3.3 - Waves

Student Learning Outcomes

At the end of the unit students can:

	Give examples of transverse (electromagnetic spectrum) & longitudinal(sound) waves and know how they are propagated.
	Use the following terms correctly: Wavelength, λ (m), Amplitude, A (m),Frequency, f (Hz), Period, T (s) , phase
	Draw the resultant wave when two waves are superimposed.
	Understand the causes of constructive & destructive interference
	Use the terms node and antinode correctly.
	Understand diffraction of waves.
	Understand the importance of Young's expt.
	Solve problems involving Young's expt.

Standing Waves

	Understand how standing waves are formed.
	Use the terms nodes, antinodes, harmonics, overtones, fundamental, resonance correctly.
	Draw appropriate diagrams of standing waves in pipes and strings.
	Solve problems involving standing waves in pipes and strings.

Beats

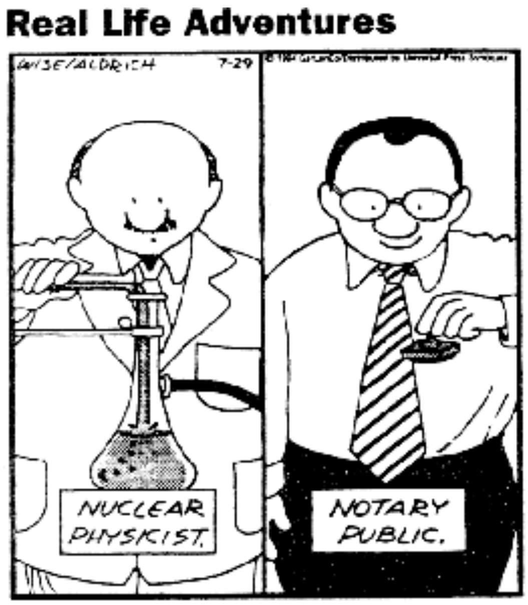
	Understand how beats are formed and know how to find the beat frequency

Diffraction Grating

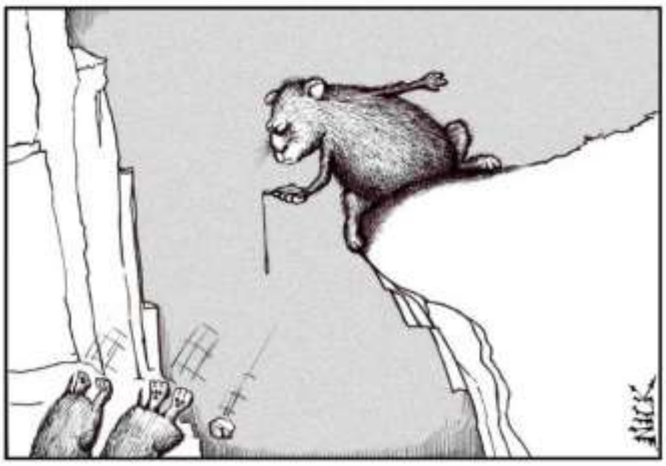
	Recognise a diffraction grating
	Use the diffraction grating formula to solve problems
	Understand the different effects produced by double and multiple slits.

Doppler Effect

	Understand what the Doppler Effect is and how it is formed.
	Draw the Doppler Effect diagram
	Solve problems using the Doppler Effect formula.



Jobs in which nobody understands what you do.



Fluffy, the "Galileo of the Lemmings," with his stopwatch.

Level 3 Physics Doppler, Standing Waves, Interference and Diffraction

equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$d\sin\theta = n\lambda$	d		1.
	θ		
	n		
	λ		
$n\lambda = \frac{dx}{L}$	x		2.
	L		
$v = f\lambda$	v		3.
	f		
	λ		
$f' = f\frac{v_w}{v_w \pm v_s}$	f'		4.
	f		
	v_w		
	v_s		

Be familiar with the NCEA standard: what COULD BE on the exam:

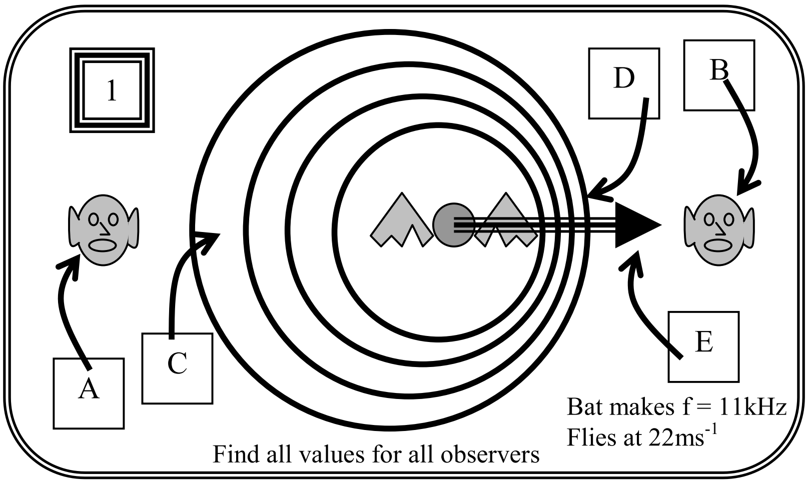
- interference (quantitative) of electromagnetic and sound waves, including multi-slit interference and diffraction gratings;
- standing waves in strings and pipes;
- harmonics and overtones;
- resonance;
- beats;
- Doppler Effect (stationary observer for mechanical waves).

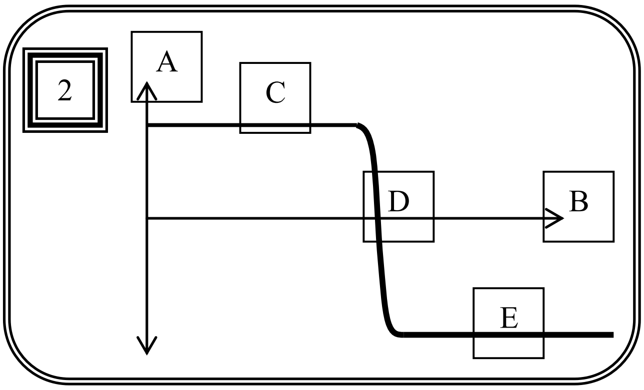
Know the MEANINGS of the key-words or common terms

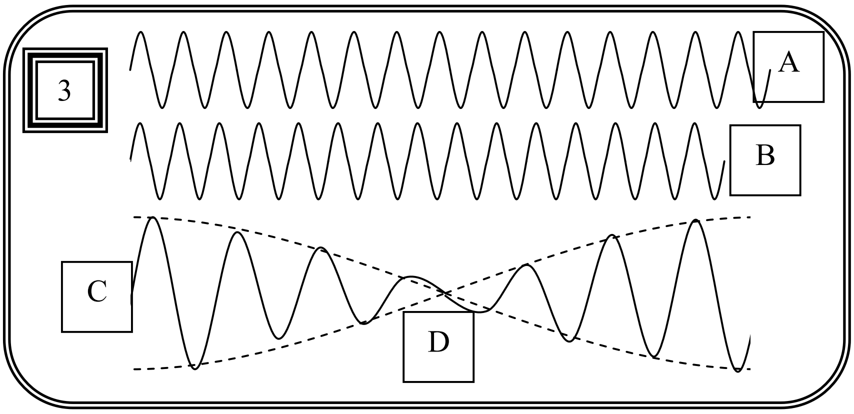
1. interference
2. diffraction
3. constructive interference
4. destructive interference
5. antinodes
6. nodes
7. in phase vs out of phase
8. diffraction grating
9. monochromatic light
10. fringes
11. central maxima
12. order
13. path difference
14. Young's Double Slit Experiment
15. beats
16. Doppler Effect
17. apparent frequency
18. apparent wavelength
19. red shift
20. blue shift
21. standing wave
22. open pipe
23. closed pipe
24. strings
25. fundamental
26. harmonics
27. overtones
28. timbre
29. longitudinal
30. transverse
31. progressive wave (traveling wave)
32. wavelength
33. frequency
34. lines per mm
35. distance between lines
36. wave speed vs source speed

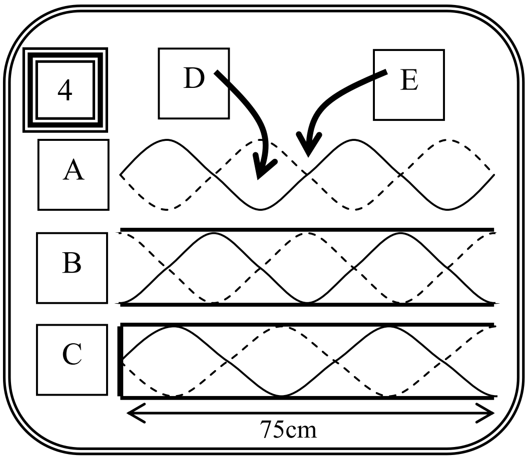
Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

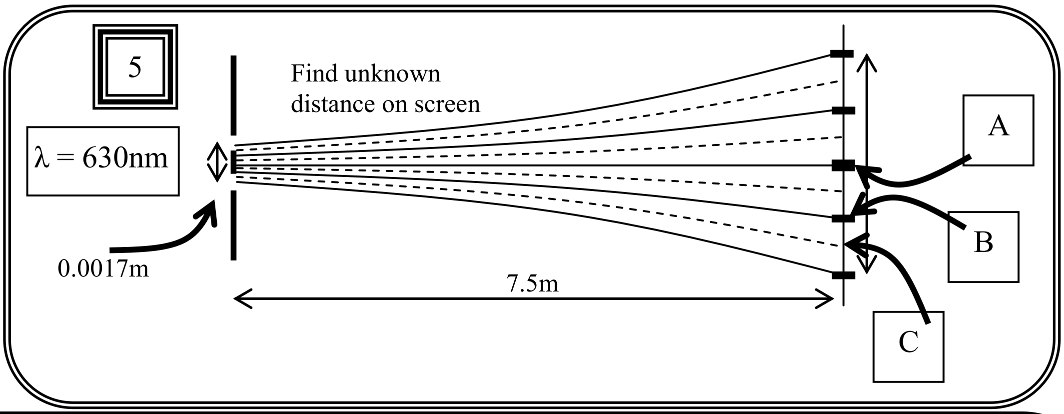
(and know the details, labels, possible equations and *explanations* that accompany them)

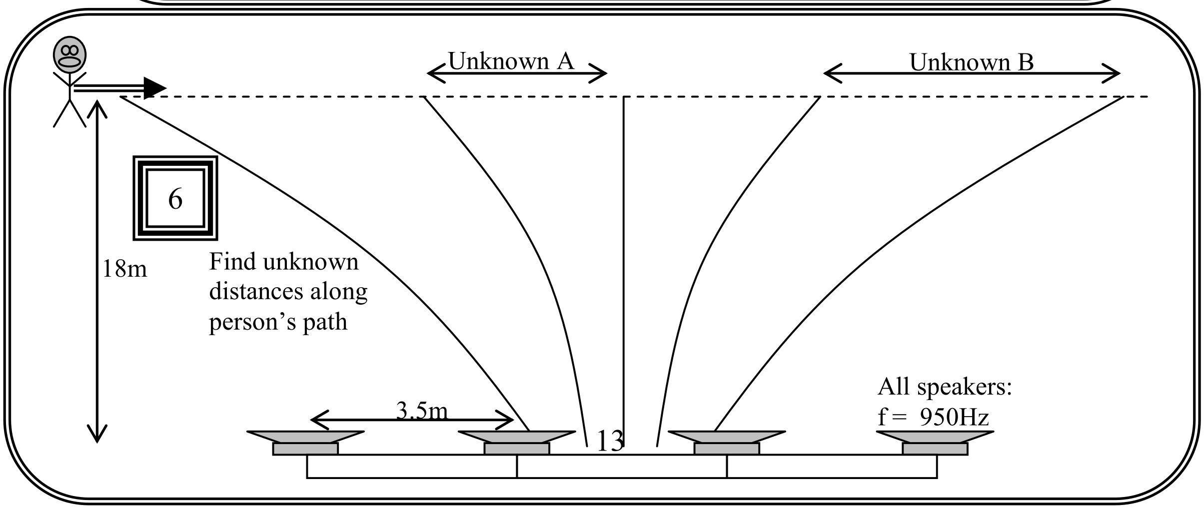












Level 3 Physics Translational & Circular Motion Review Sheet

equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$F_{net} = ma$	F_{NET}		1.
	m		
	a		
$p = mv$	ρ		2.
	v		
$\Delta p = F\Delta t$	Δρ		3.
	F		
	Δt		
$\Delta E_p = mgh$	ΔE_P		4.
	g		
	h		
$W = Fd$	W		5.
	d		
$E_{K(LIN)} = \frac{1}{2}mv^2$	$E_{K(LIN)}$		6.
	v		
$F_g = \frac{GMm}{r^2}$	F_G		7.
	G		
	M		
	m		
	r		
$F_c = \frac{mv^2}{r}$	F_C		8.
	m		
	v		
	r		

Note: Equations for Centre of Mass usually NOT given: $m_1 x = m_2(d - x)$ OR $r = \frac{m_1 r_1 + m_2 r_2 + m_3 r_3 + ...}{m_1 + m_2 + m_3 + ...}$

Be familiar with the NCEA standard: what COULD be on the exam:

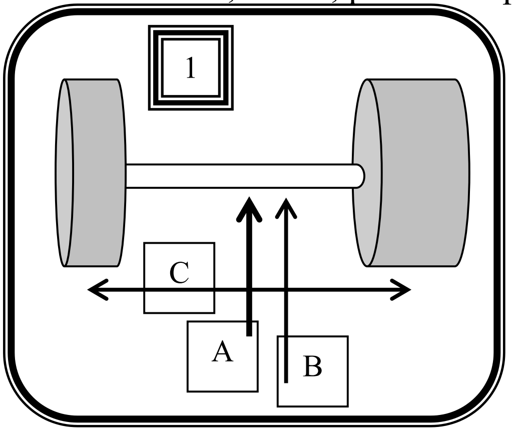
- Centre of mass (1 and 2 dimensions).
- Conservation of momentum and impulse (2 dimensions only).
- Velocity & acceleration of, and resultant force on, objects moving in a circle under the influence of 2 or more forces
- Newton's Law of gravitation,
- Satellite motion.

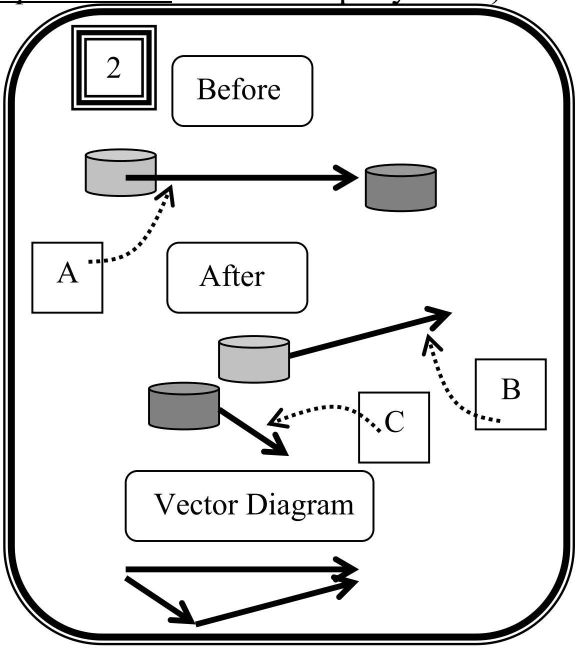
Know the MEANINGS of the key-words or common terms

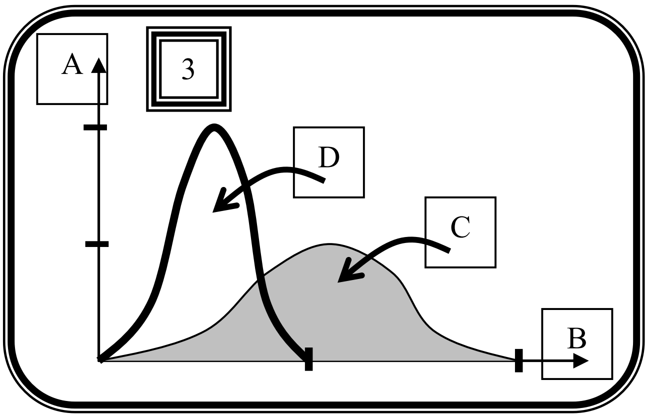
1. center of gravity
2. center of mass
3. translational motion
4. momentum
5. impulse
6. conservation of momentum
7. components
8. elastic collision
9. inelastic collision
10. gravitational potential energy
11. kinetic energy
12. work
13. conservation of energy
14. equilibrium
15. free body force diagram
16. circular motion
17. friction
18. tension
19. weight
20. weightless
21. negative g's
22. centripetal force
23. centripetal acceleration
24. conical pendulum
25. banked corner
26. Newton's law of gravitation
27. satellite motion

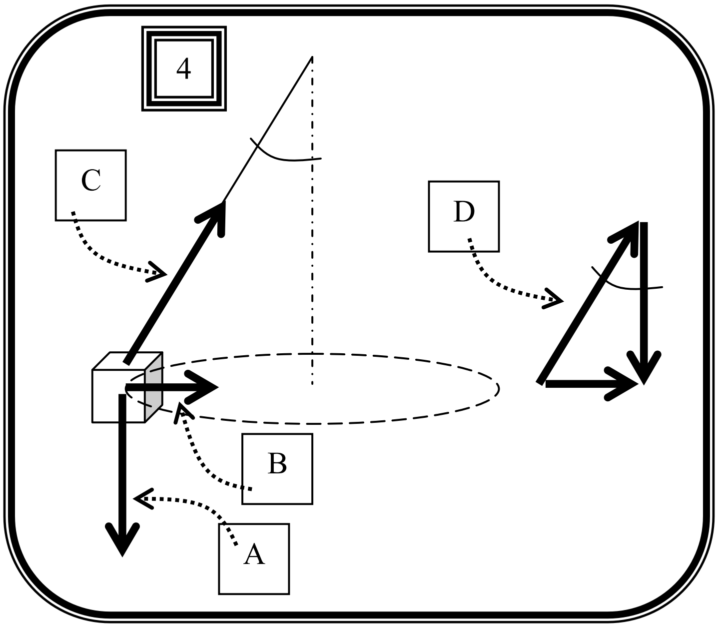
Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

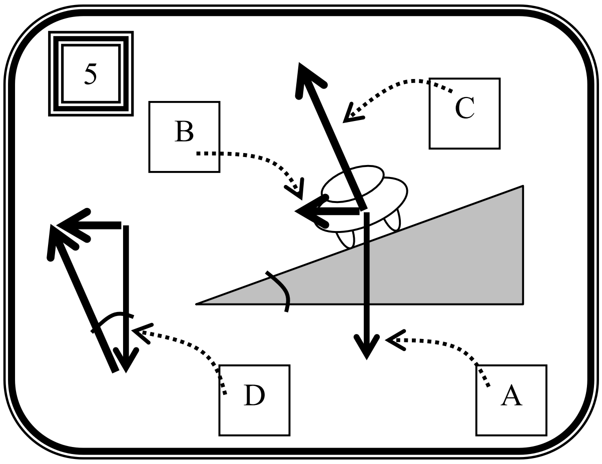
(and know the details, labels, possible equations and *explanations* that accompany them)

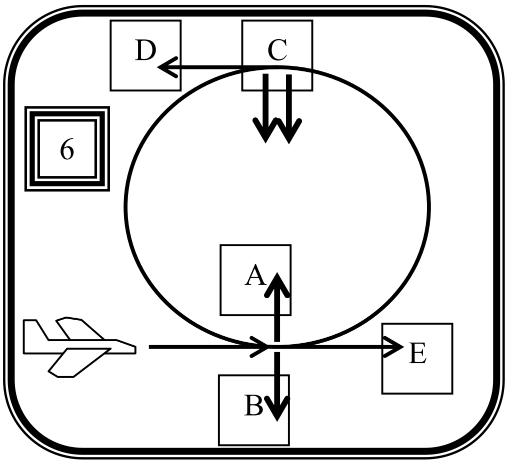


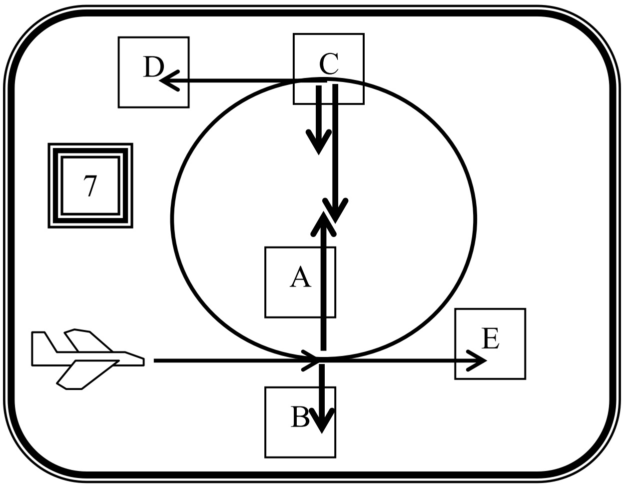












Level 3 Physics Rotational Motion Review Sheet

equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$d = r\theta$	d		1,2,3.
	r		
	θ		
$v = r\omega$	v		
	ω		
$a = r\alpha$	a		
	α		
$\omega = \frac{\Delta\theta}{\Delta t}$	Δ θ		4.
	Δ t		
$\alpha = \frac{\Delta\omega}{\Delta t}$	Δ ω		5.
$\omega = 2\pi f$	ω		6.
	f		
$f = \frac{1}{T}$	T		7.
$E_{K(ROT)} = \frac{1}{2}I\omega^2$	$E_{K(ROT)}$		8.
	I		
$\omega_f = \omega_i + \alpha t$	ω_f		9,10,11,12.
	ω_i		
$\theta = \frac{(\omega_i + \omega_f)}{2}t$	α		
$\omega_f^2 = \omega_i^2 + 2\alpha\theta$	θ		
$\theta = \omega_i t + \frac{1}{2}\alpha t^2$	t		
$\tau = I\alpha$	τ		13.
	I		
	α		
$\tau = Fr$	F		14.
	r		
$L = mvr$	L		15.
	m		
	v		
$L = I\omega$			16.

Be familiar with the NCEA standard: what COULD be on the exam:

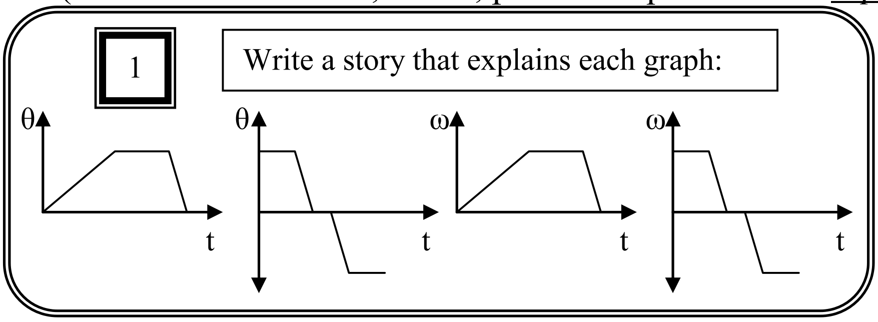
- **Rotational motion with constant angular acceleration;**
- **torque;**
- **rotational inertia;**
- **conservation of angular momentum;**
- **conservation of energy**

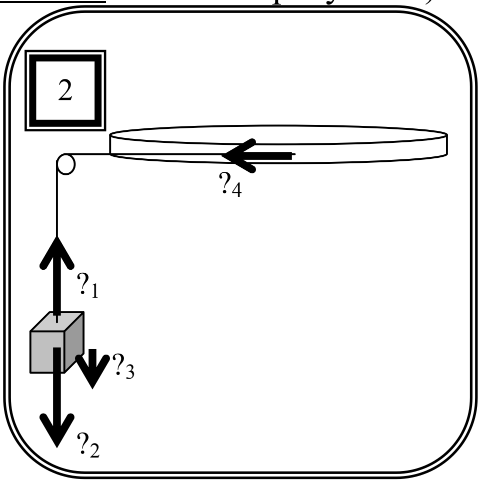
Know the MEANINGS of the key-words or common terms

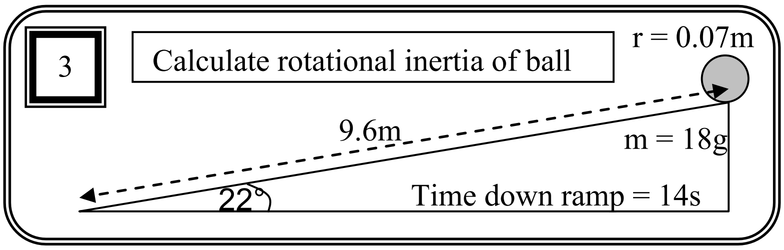
1. translational motion
2. rotational motion (angular motion)
3. angular displacement
4. angular velocity
5. angular acceleration
6. angular frequency
7. frequency
8. period
9. linear displacement
10. linear velocity (tangential)
11. linear acceleration (centripetal)
12. moment of inertia (rotational inertia)
13. angular momentum
14. linear momentum
15. torque
16. Law of conservation of angular momentum
17. Law of conservation of energy
18. rotational kinetic energy
19. linear kinetic energy
20. gravitational potential energy
21. radian
22. radian per second
23. radian per second squared
24. kilogram meter squared
25. kilogram meter squared per second

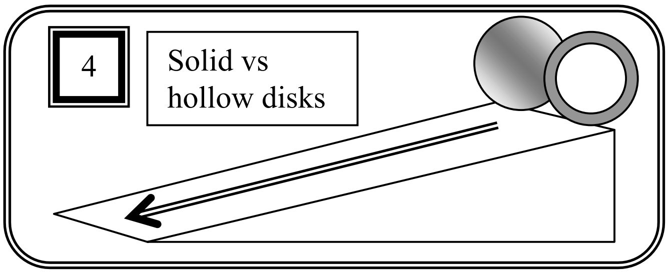
Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

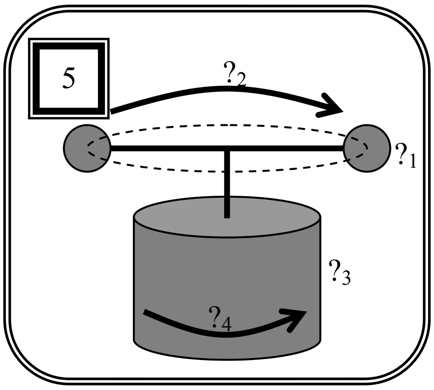
(and know the details, labels, possible equations and *explanations* that accompany them)

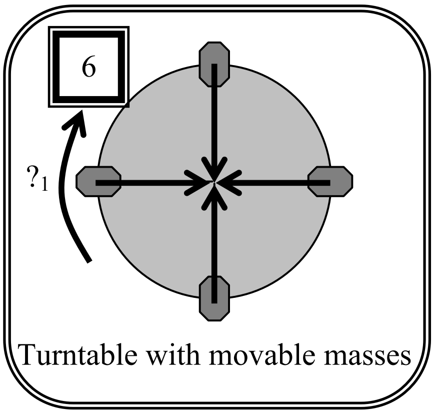


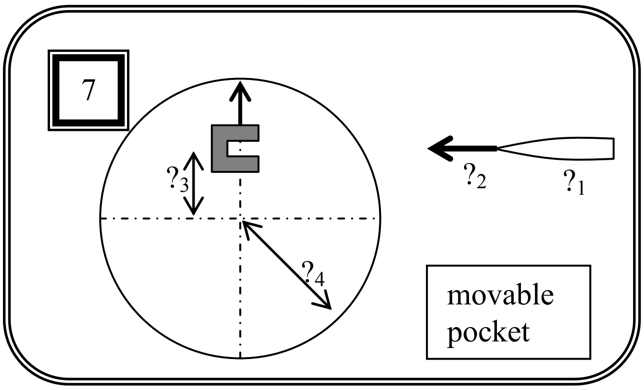












Level 3 Physics Simple Harmonic Motion Review Sheet

equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$\omega = 2\pi f$	ω		1.
	f		
$f = \frac{1}{T}$	T		2.
$a = -\omega^2 y$	a		3.
	ω		
	y		
$F = -ky$	F		4.
	k		
$T = 2\pi\sqrt{\frac{l}{g}}$	T		5.
	l		
	g		
$T = 2\pi\sqrt{\frac{m}{k}}$	T		6.
	m		
$E = \frac{1}{2}ky^2$	E		7.
$y = A\sin\omega t$	A		8/9/10.
	ω		
	t		
$v = A\omega\cos\omega t$	v		
$a = -A\omega^2\sin\omega t$	a		
$y = A\cos\omega t$			11/12/13.
$v = -A\omega\sin\omega t$			
$a = -A\omega^2\cos\omega t$			

Be familiar with the NCEA standard: what COULD be on the exam:

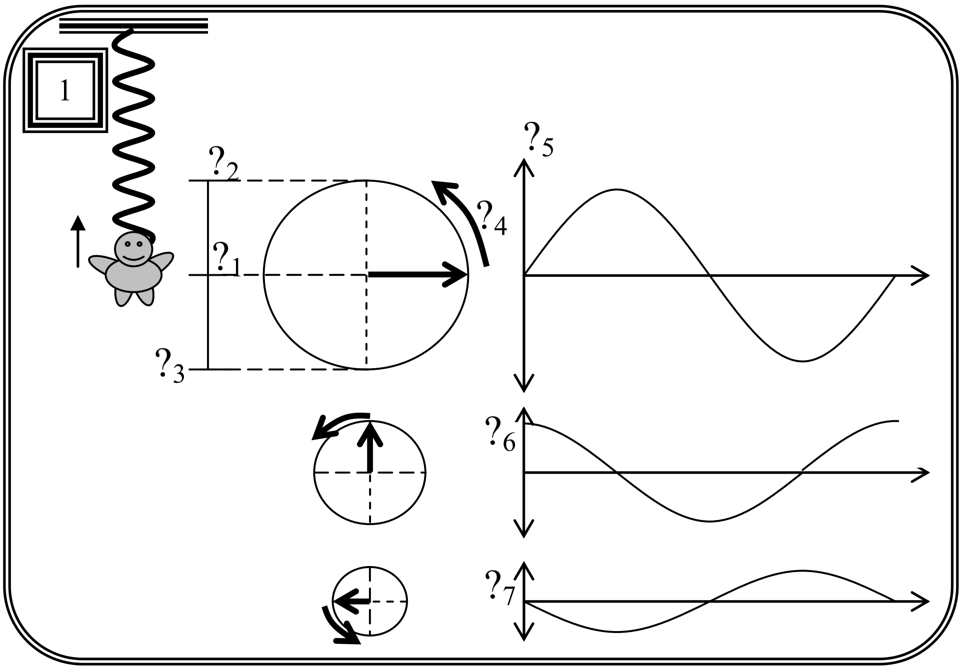
- **The conditions for simple harmonic motion (SHM);**
- **Angular frequency;**
- **Variation of displacement, velocity & acceleration with time;**
- **Phasor diagrams;**
- **Reference circles;**
- **Damped and driven systems**
- **Resonance;**
- **conservation of energy**

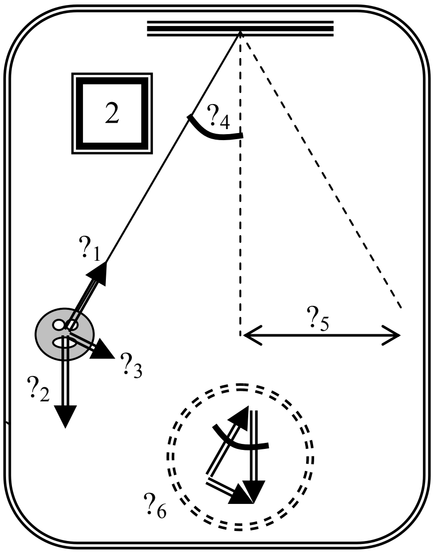
Know the MEANINGS of the key-words or common terms

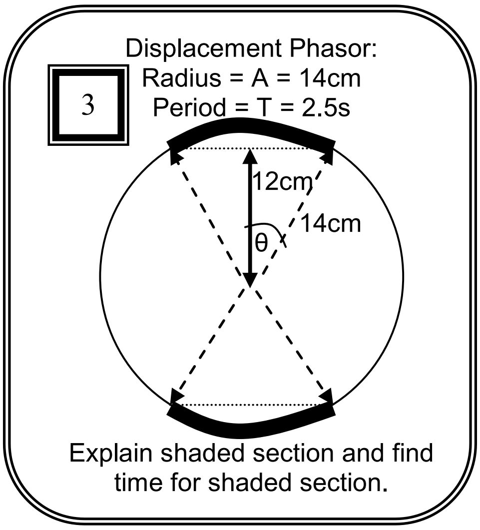
1. simple harmonic motion rule #1
2. simple harmonic motion rule #2
3. equilibrium
4. amplitude
5. period
6. frequency
7. angular frequency
8. linear displacement
9. linear velocity
10. linear acceleration
11. locations of v_{max} and a_{max}.
12. angular displacement
13. angular velocity
14. principle of conservation of energy
15. elastic potential energy
16. gravitational potential energy
17. kinetic energy
18. force constant (spring constant)
19. restorative force
20. free body force diagram
21. friction
22. weight
23. tension
24. phasor
25. reference circle
26. forced SHM
27. resonance
28. resonant frequency
29. damping or damped SHM
30. radian

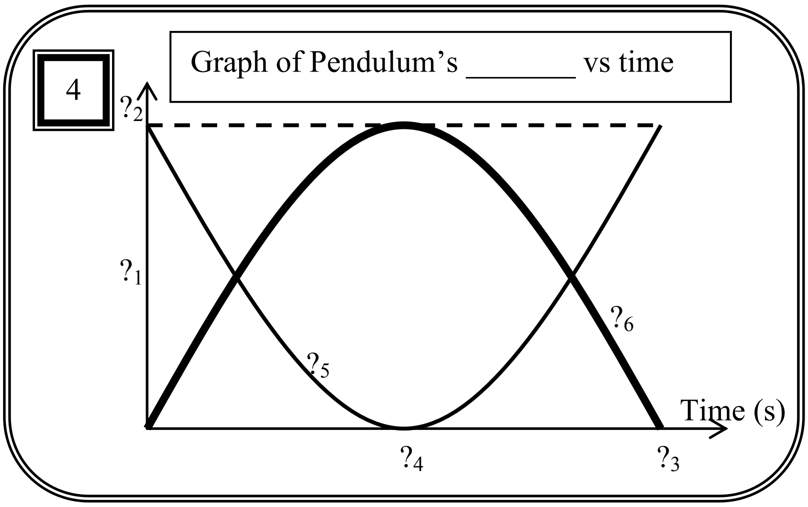
Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

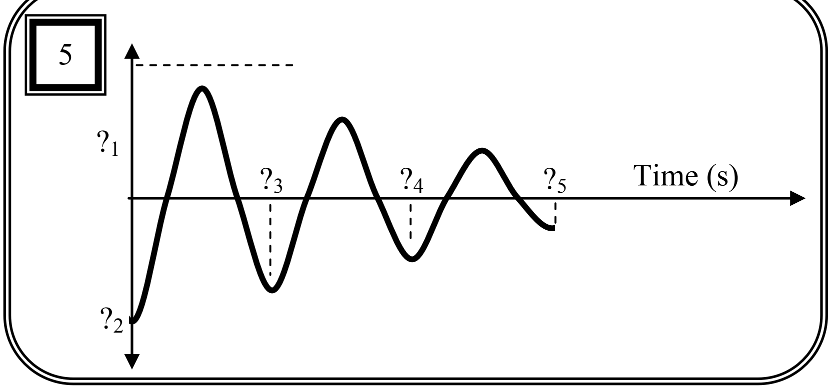
(and know the details, labels, possible equations and *explanations* that accompany them)











Level 3 Physics Internal Resistance, Kirchoff & Capacitance

prefixes, equations, NCEA language, key terms, equation rearrangements and diagrams

KNOW the PREFIXES and how to change them into "usable" units:

symbol	name	meaning	Power of 10 to use in equation	examples
c				cm
m	milli	one thousand**th**	number x 10^{-3}	mm, mF, mA, mV
μ				μF, μm, μA
n				nF, nm
p				pF, pm
k				kΩ
M				MΩ
G				GΩ

KNOW THE EQUATIONS:

Equation	Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper.
$V = Ed$	V E d	1.
$\Delta E = Vq$	Δ E q	2.
$E_{cap} = \frac{1}{2}QV$	E_{CAP} Q	3.
$Q = CV$	C	4.
$C = \frac{\varepsilon_o \varepsilon_r A}{d}$	ε_o ε_r A d	5.
$\tau = RC$	τ R	6.
$V = IR$	V I	7.
$P = VI$	P	8.
$R_T = R_1 + R_2 + \ldots$	R_T	9.
$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$	R_T	10.
$C_T = C_1 + C_2 + C_3 + \ldots$	C_T	11.
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$	C_T	12.

Be familiar with the NCEA standard: what COULD BE on the exam:

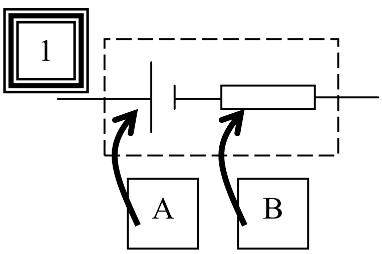
- Internal resistance;
- simple application of Kirchhoff's Laws;
- parallel plate capacitor;
- capacitance;
- dielectrics;
- series and parallel capacitors;
- charge/time, voltage/time and current/time graphs for a capacitor;
- time constant;
- energy stored in a capacitor.

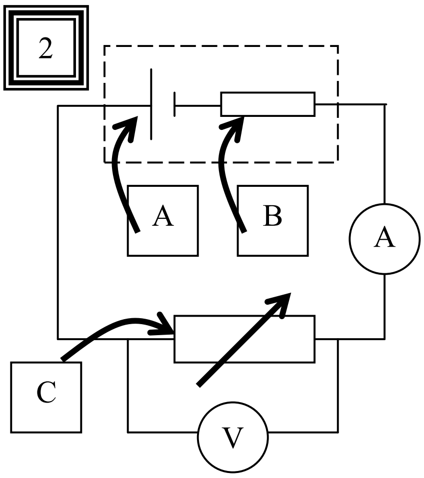
Know the MEANINGS of the key-words or common terms

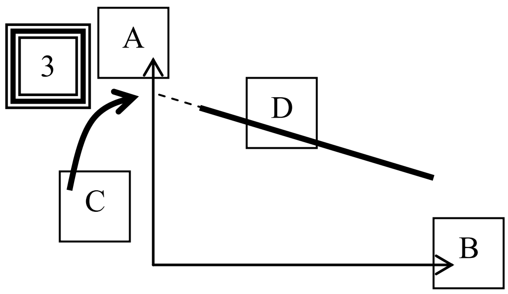
1. internal resistance
2. EMF
3. voltage
4. potential difference
5. current
6. conventional current
7. galvanometer
8. multimeter
9. charge
10. resistance
11. ohmic conductor
12. non-ohmic conductor
13. insulator
14. kirchhoff's 1st law
15. kirchhoff's 2nd law
16. capacitor
17. capacitance
18. electric field
19. parallel plate capacitor
20. coiled capacitor
21. variable capacitor
22. overlapping area
23. separation distance
24. time constant
25. Dielectric
26. parallel
27. series
28. electric potential energy
29. farad
30. microfarad
31. culoumbs
32. ohm
33. kilo-ohm

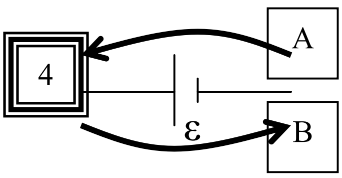
Be familiar with the COMMON DIAGRAMS in this unit:

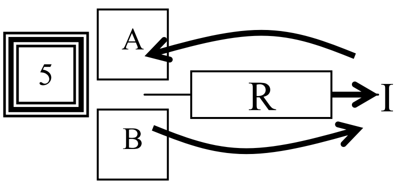
(and know the details, labels, possible equations and *explanations* that accompany them)

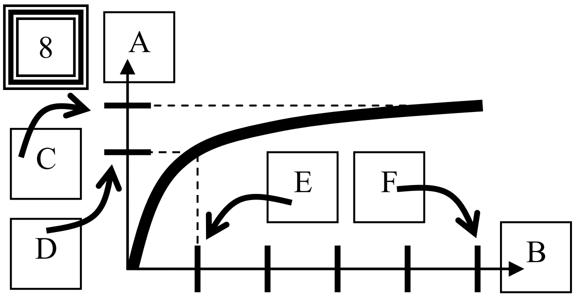


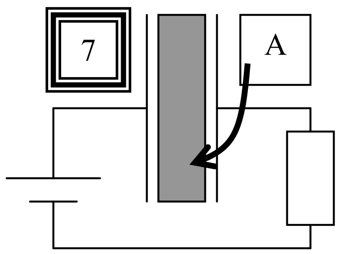


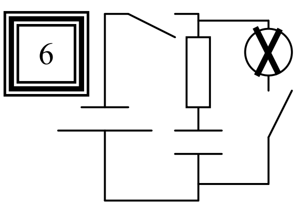


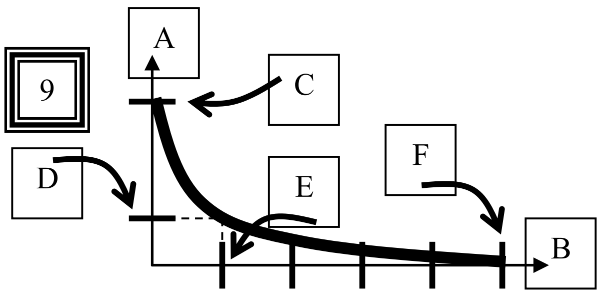












Level 3 Physics Induced Voltage, Inductors & Transformers

prefixes, equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation		Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$\phi = BA$	ϕ		1.
	B		
	A		
$\phi = LI$	L		2.
	I		
$\varepsilon = -L\frac{\Delta I}{\Delta t}$	ε		3.
	L		
	Δ I		
	Δ t		
$\varepsilon = -\frac{\Delta\phi}{\Delta t}$	ε		4.
	Δ ϕ		
$\varepsilon = -M\frac{\Delta I}{\Delta t}$	ε		5.
	M		
$\frac{N_p}{N_s} = \frac{V_p}{V_s}$	N_P		6.
	N_S		
	V_P		
	V_S		
$E = \frac{1}{2}LI^2$	E		7.
	L		
	I		
$\tau = \frac{L}{R}$	τ		8.
	R		

Be familiar with the NCEA standard: what COULD BE on the exam:

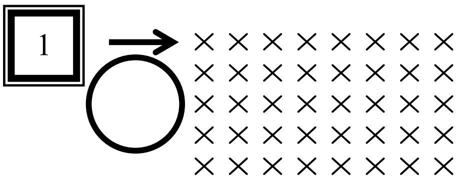
- magnetic flux;
- magnetic flux density;
- Faraday's Law;
- Lenz's Law;
- voltage/time and current/time graphs for an inductor;
- time constant;
- self inductance;
- the inductor;
- energy stored in an inductor;
- the transformer;

Know the MEANINGS of the key-words or common terms

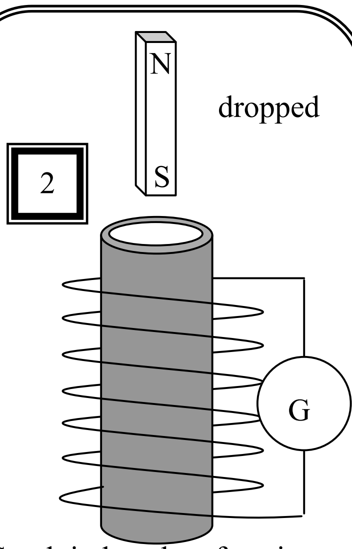
1. magnetic flux
2. faraday's law
3. lenz's law
4. electromagnetic induction
5. EMF
6. inductance (self inductance)
7. turns
8. soft iron core
9. time constant for inductor
10. kirchhoff's voltage laws
11. induced EMF
12. induced current
13. induced magnetic field
14. transformer
15. mutual inductance
16. primary coil
17. secondary coil
18. step-up, step-down, isolating
19. generator
20. direct current (DC)
21. alternating current
22. galvanometer
23. henry
24. weber
25. ohm
26. amps
27. volts

Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

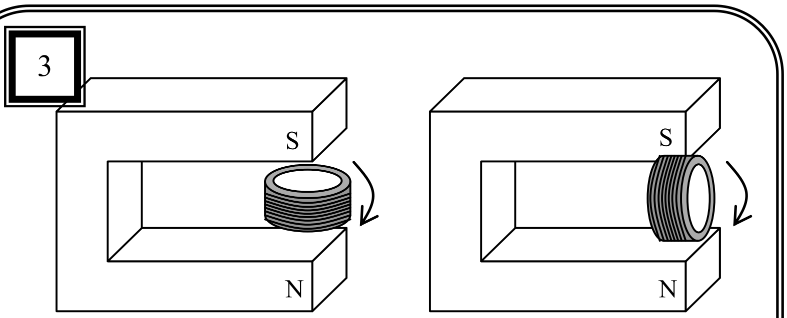
(and know the details, labels, possible equations and *explanations* that accompany them)



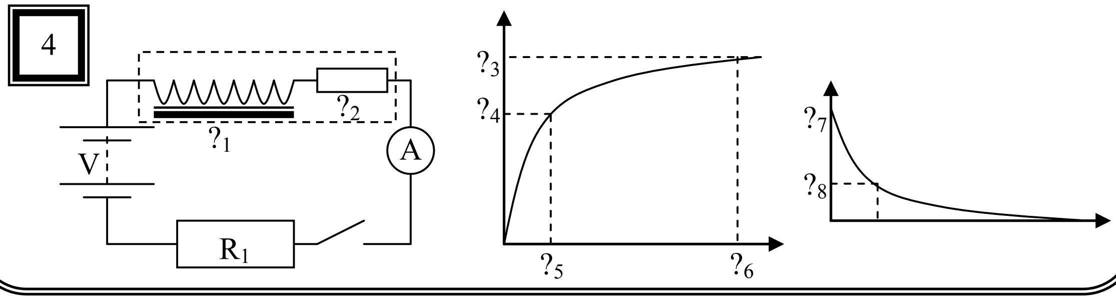
Graph induced emf vs time and explain

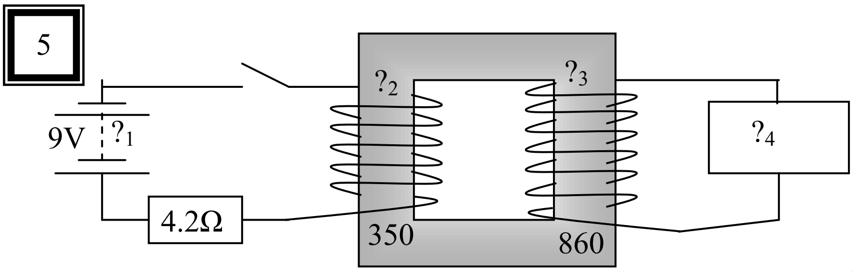


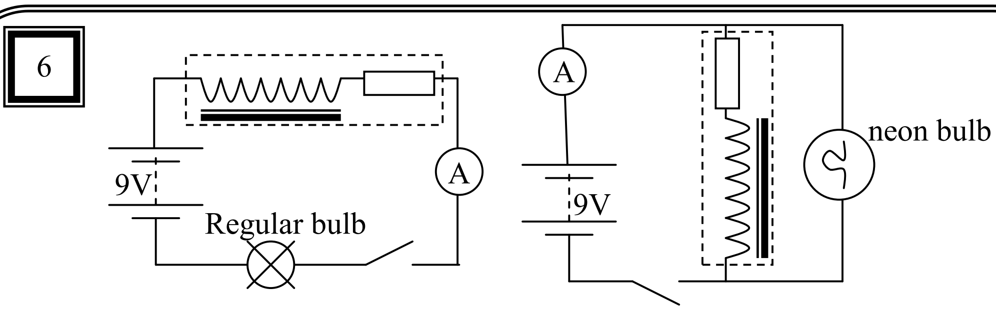
Graph induced emf vs time and explain



Coil rotating vertically:
Graph flux vs t and induced emf vs t and explain







Compare and contrast the 2 circuits when switch is closed AND opened

Level 3 Physics Alternating Current Review Sheet

equations, NCEA language, key terms and common diagrams

KNOW THE EQUATIONS:

Equation	Symbol	Symbol's **complete** name And SI unit	Situation where equation is most commonly used (or notes about this equation). Use your own paper
$I = I_{MAX} \sin\omega t$	I		1, 2.
	I_{MAX}		
	ω		
	t		
$V = V_{MAX} \sin\omega t$	V		
	V_{MAX}		
$I_{MAX} = \sqrt{2} I_{rms}$	I_{MAX}		3, 4.
	I_{RMS}		
$V_{MAX} = \sqrt{2} V_{rms}$	V_{MAX}		
	V_{RMS}		
$X_C = \frac{1}{\omega C}$	X_C		5, 6.
	ω		
	C		
$X_L = \omega L$	X_L		
	L		
$\omega = 2\pi f$	ω		7.
	f		
$V = IZ$	V		8.
	I		
	Z		

Be familiar with the NCEA standard: what COULD be on the exam:

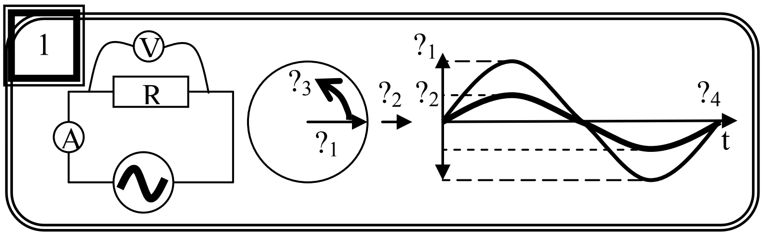
- resistor carrying direct current and alternating current;
- peak and rms voltage and current;
- voltage and current and their phase relationship in LR and CR series circuits;
- phasor diagrams;
- reactance and impedance and their frequency dependence in a series circuit;
- resonance in LCR circuits.

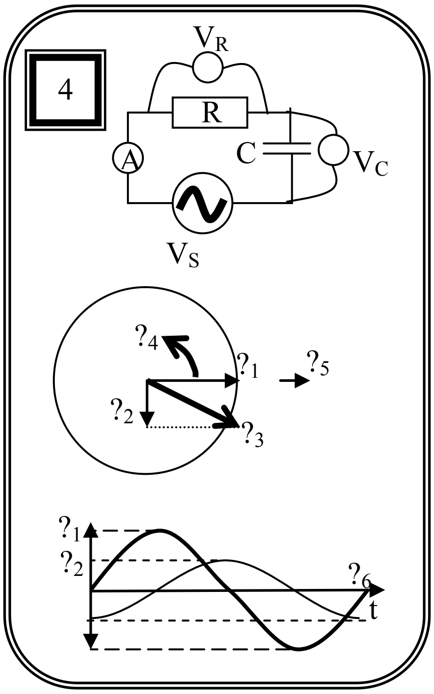
Know the MEANINGS of the key-words or common terms

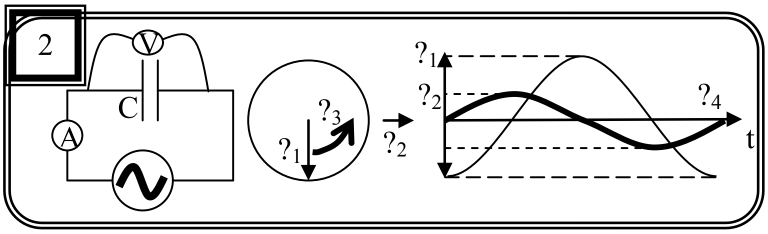
1. alternating current (AC)
2. direct current (DC)
3. generator
4. mains voltage (NZ)
5. Peak Voltage (and peak current)
6. RMS
7. phasor
8. resistance
9. capacitance
10. inductance
11. reactance of capacitor
12. reactance of inductor
13. impedance
14. resistor in AC
15. capacitor in AC
16. inductor in AC
17. LR AC circuit
18. RC AC circuit
19. LRC AC circuit
20. resonance
21. frequency
22. angular frequency
23. oscilloscope
24. transformer
25. Farad
26. Henry
27. Ohm

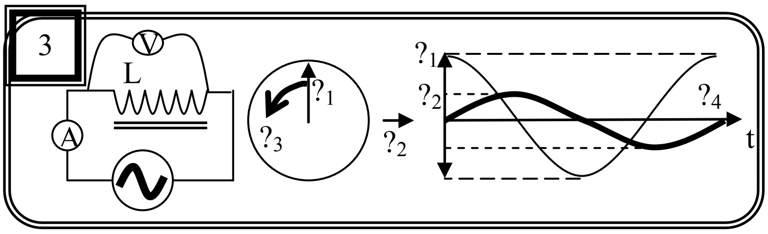
Be familiar with the COMMON DIAGRAMS and GRAPHS in this unit:

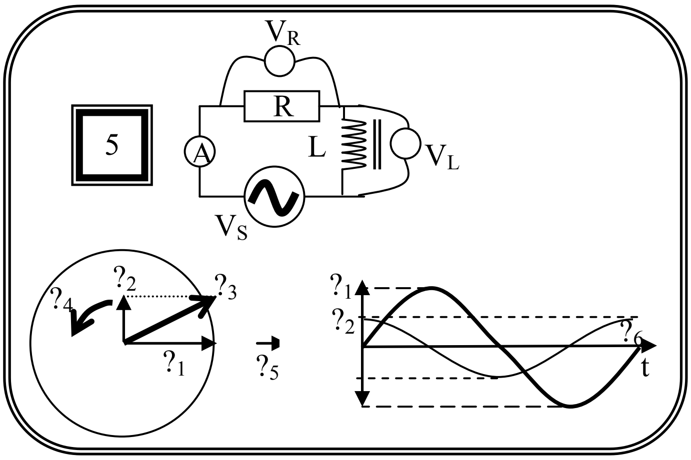
(and know the details, labels, possible equations and *explanations* that accompany them)

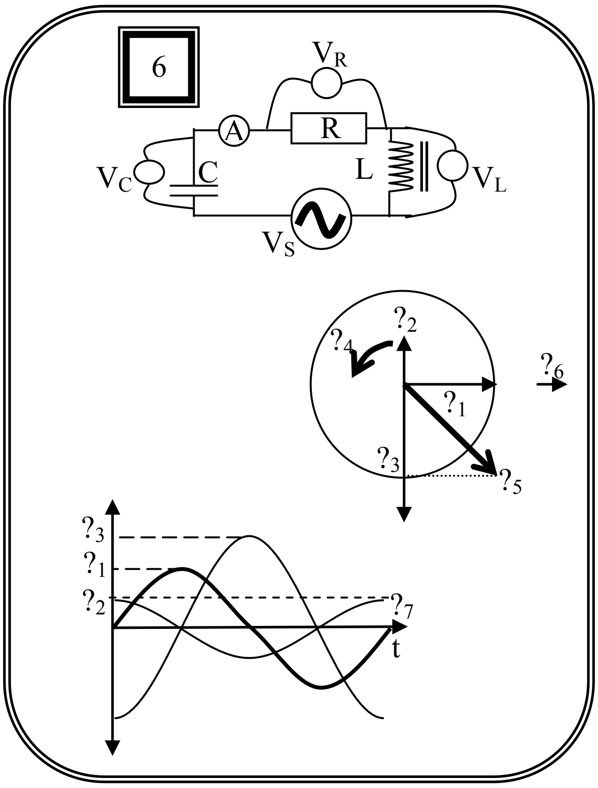


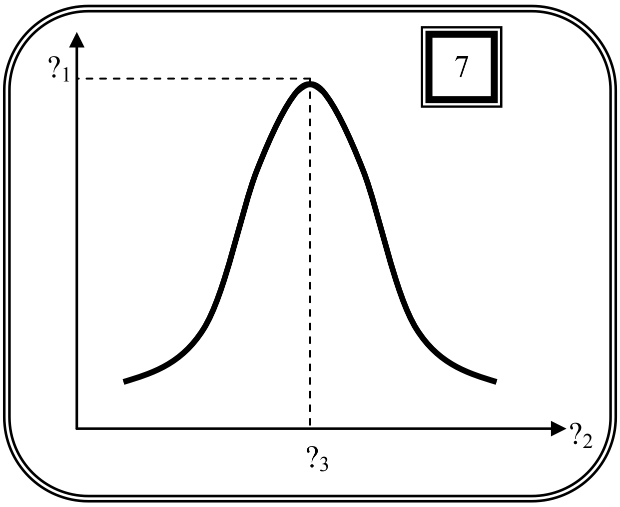










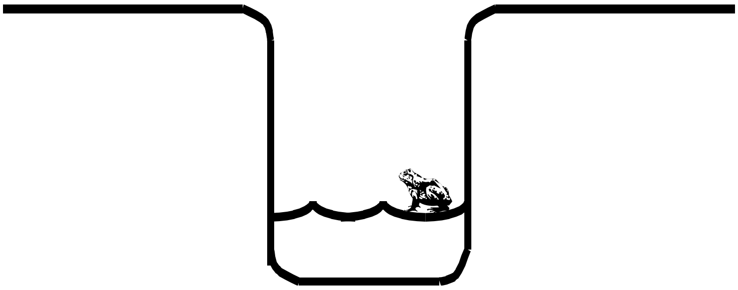


Standing Waves & Beats Revision Question Set

$d\sin\theta = n\lambda$ $\qquad n\lambda = \frac{dx}{L}$ $\qquad f' = f\frac{v_w}{v_w \pm v_s}$ $\qquad v = f\lambda$ $\qquad f = \frac{1}{T}$

QUESTION ONE: frog in the hole

The Bornean Tree Hole Frog makes its mating call in a hollow filled with water. This allows the song to carry further than if the frog was in the open.



(a) The frog is taking advantage of a physics phenomenon or principle. Name this.

The hollow in the picture acts like a tube closed at one end.

(b) Make a diagram to show the simplest standing wave that can be produced in the hollow.

The hole is 0.640m deep.

(c) Show that the fundamental frequency of the frog's song is 129Hz. Use the speed of sound in air 330 ms^{-1}

(d) State the frequency of the third harmonic that will be heard.

After a heavy rain the level of water in the hollow rises.

(e) Explain how the frog can compensate for this change?

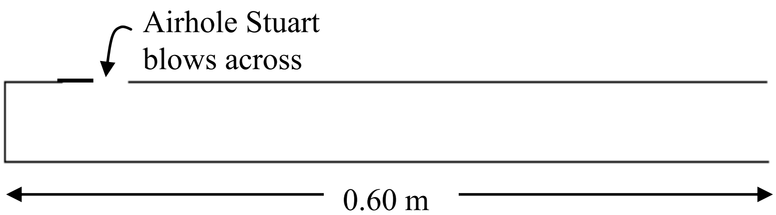
A researcher studying Tree Hole Frogs moves the frog into an open-ended, hollow log which is also 0.640m long.

(f) Explain why the fundamental frequency of the frog's song in the log would be different to the fundamental frequency in the hole.

QUESTION TWO: the flute

Stuart is a flute player. His flute can be modelled as a 0.60 m long metal tube, open at one end and closed at the other. It has a hole near the closed end that is blown across to make the air vibrate. There are regularly spaced holes along its length, which are closed unless Stuart pushes a key to open one of them.

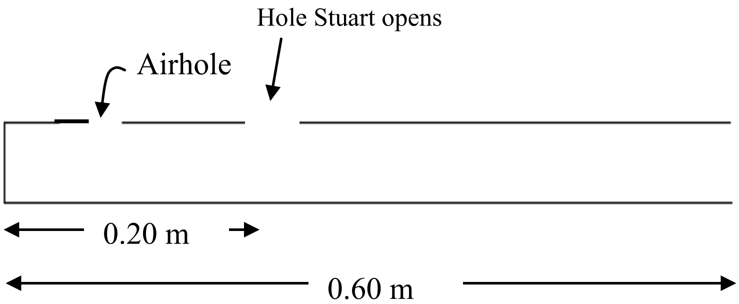
A simple diagram of the flute with its holes closed is shown. On a particular day that Stuart plays, the speed of sound can be taken as 340 ms^{-1}.



(a) On the diagram above, sketch the shape of the fundamental standing wave that can resonate in this tube

(b) Calculate the wavelength of this fundamental standing wave.

(c) Stuart discovers that if he blows a little too hard he hears a higher pitched note. Explain why this happens.



(d) When he opens a hole which is 20 cm from the closed end, Stuart can cause the next resonant frequency above the fundamental to sound when he blows. Sketch a picture of this resonance in the tube

(e) Explain why opening this hole allows the next resonant frequency to sound.

(f) Calculate the size of this next higher frequency (with the hole open 20 cm from the closed end.)

(g) While playing a note of 560 Hz, Stuart hears his friend Julia playing nearly the same note on her flute at the same time. He notices a beat frequency of 5.0 Hz. What possible frequency or frequencies is Julia playing?

(h) Explain how this beat frequency arises. Sketch a graphical representation of the situation to help your explanation.

QUESTION THREE: waves on wires

A guitar player also uses standing waves to generate a musical note. A certain string on a guitar produced a fundamental note of 128 Hz. The speed of sound in air is again 340ms^{-1}.

(a) If the string has a length of 75 cm, what is the speed of the wave on the guitar string?

(b) Stuart tunes his flute against a note on the piano. He notices that even though he plays the same note as the piano, they have a different 'quality' of sound. Why is this?

(c) (i) Sketch the 3rd harmonic vibration of this string and calculate its frequency.

(ii) State the fundamental S.I. unit for frequency. (Not Hz)

Doppler Revision Question Set

$d\sin\theta = n\lambda \qquad n\lambda = \frac{dx}{L} \qquad f' = f\frac{v_w}{v_w \pm v_s} \qquad v = f\lambda \qquad f = \frac{1}{T}$

QUESTION ONE: Voyager Spacecraft. NASA launched the Voyager 1 interstellar mission in 1977. The twin Voyager 1 and 2 spacecraft opened new vistas in space by greatly expanding our knowledge of Jupiter and Saturn and beyond.

At more than thirteen billion kilometres from the sun, Voyager 1 is the most distant object from Earth built by humanity. Both craft are still sending back data.

(a) The frequency of a radio signal sent from Voyager 1 would be higher than the apparent frequency received on earth. Name the phenomenon that causes this?

(b) Explain why the signal received on earth will be at a lower frequency than that emitted by the Voyager craft.

(c) Calculate the frequency of the signal received on Earth from Voyager 1 if the transmission frequency is 4.00000 x 10^6 Hz. The spacecraft is travelling away from Earth at a speed of 28 853 ms^{-1}. (use c=299 792 458 ms^{-1})
Ignore relativistic effects.

(d) Explain how NASA scientists can measure the difference in frequency between two waves.

(e) A star under observation is moving at a high velocity away from the astronomer. Explain the effect this will have on the wavelength of the violet light emitted from the star.

QUESTION TWO: Speed Radar. The traffic police speed radar uses the idea of Doppler Effect to check the speed of oncoming cars.

(a) Describe the phenomenon of "Doppler Effect".

The transmitter in the speed radar sends out microwaves of frequency 1.276 x 10^{10} Hz. The speed of the wave is 3.00 x 10^8 ms^{-1}.

(b) Calculate the wavelength of the microwaves. Write down your answer to the correct number of significant figures.

(c) A traffic police car is parked by the road side. The policeman in the car sees an ambulance approaching. The speed radar shows that the ambulance is approaching him at a constant speed of 25.0 ms^{-1}. The actual frequency of the siren is 630 Hz. The speed of sound in air is 330ms^{-1}. Calculate the apparent frequency of the sound waves heard by the policeman.

(d) Explain why the apparent frequency of sound heard by the policeman is different from the actual frequency of the siren.

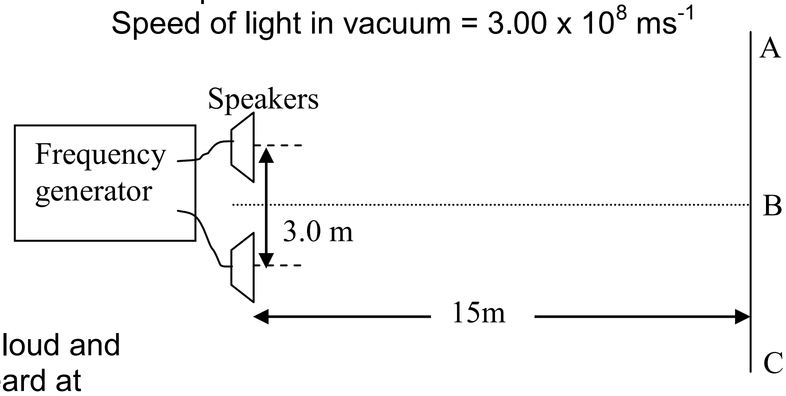
Diffraction & Interference Revision Question Set

$d\sin\theta = n\lambda \qquad n\lambda = \frac{dx}{L} \qquad f' = f\frac{v_w}{v_w \pm v_s} \qquad v = f\lambda \qquad f = \frac{1}{T}$

Question ONE:

Speed of sound in air = 340 ms^{-1}
Speed of light in vacuum = 3.00 x 10^{8} ms^{-1}

To investigate how sound interferes with itself, speakers can be set up in a room that doesn't reflect sound waves from the walls. In one such investigation two speakers are placed 3m apart as shown and connected to the same sound frequency generator so that they emit sound waves in phase. The distance from the speakers to the line ABC is 15 m. The frequency generator emits a signal of 680 Hz.

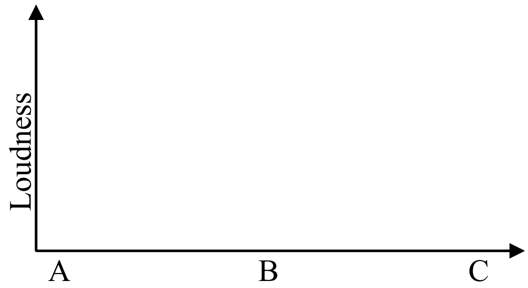


A person walking from A to C hears a pattern of loud and soft patches of sound. A strong loud sound is heard at point B.

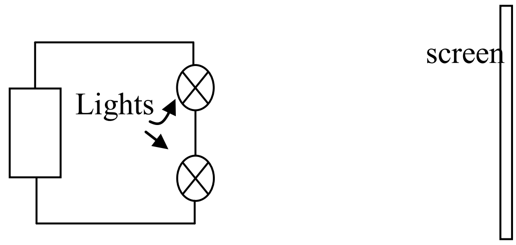
(a) What is the name given to the loud reinforcement of sound which is heard at point B?

(b) Calculate the spacing between the centres of each patch of loud sound, along the line from A to C.

(c) Sketch a graph on the axes to show how the loudness of the sound heard by a person walking from A to B to C would vary.

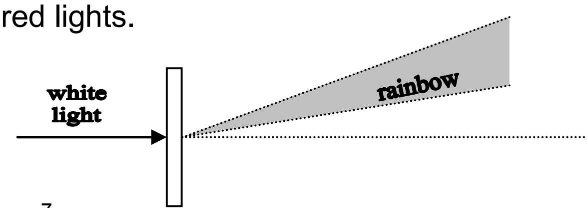


Stuart and Julia's physics teacher told them that the same effect could be observed using light and that they would see a series of regularly spaced bright spots. They set up two red light sources as shown below using red light bulbs. However, they did not observe these bright spots on a distant screen as expected.



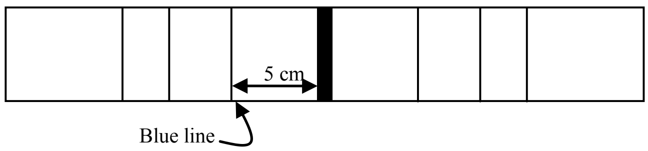
(d) Explain why they would not observe this effect with the red lights.

(e) They replaced the lights with a white light source and a diffraction grating with 1000 lines per mm. They observe a pattern as shown:



Here are some common visible light wavelengths:
λ_{red} = 7.00 x 10^{-7}m, λ_{green} = 5.00 x 10^{-7}m, λ_{blue} = 4.50 x 10^{-7}m.
Calculate how many full rainbows (visible spectra) it is possible to see on a screen.

(f) Stuart's father is an astronomer and uses a diffraction grating to analyse the light coming from stars. He looks at one star and records a pattern similar to the one shown. He knows he is looking at light from a blue coloured star and that the first line is the dominant blue one. If the diffraction grating he uses has 1,000 lines per mm and the grating is 10 cm from the screen he sees the pattern on, show that the wavelength of the first order blue line he sees is 5.00 x 10^{-7} m.

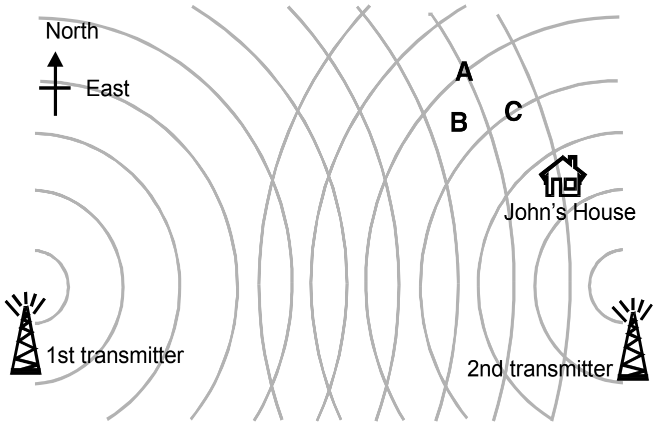


Question TWO: radio reception

John lives a long way from the nearest radio transmitter so his radio reception is poor. When a second transmitter is placed nearer his house he is astonished to find his signal gets even weaker.

(a) Use the diagram to explain why John's radio got quieter when the second transmitter started broadcasting.

(b) To which of the places, A, B or C or any combination of these, could John go to hear his favourite radio programme clearly? Explain your answer.



John drives to visit his friend Jimmy. He has his radio turned on in the car.

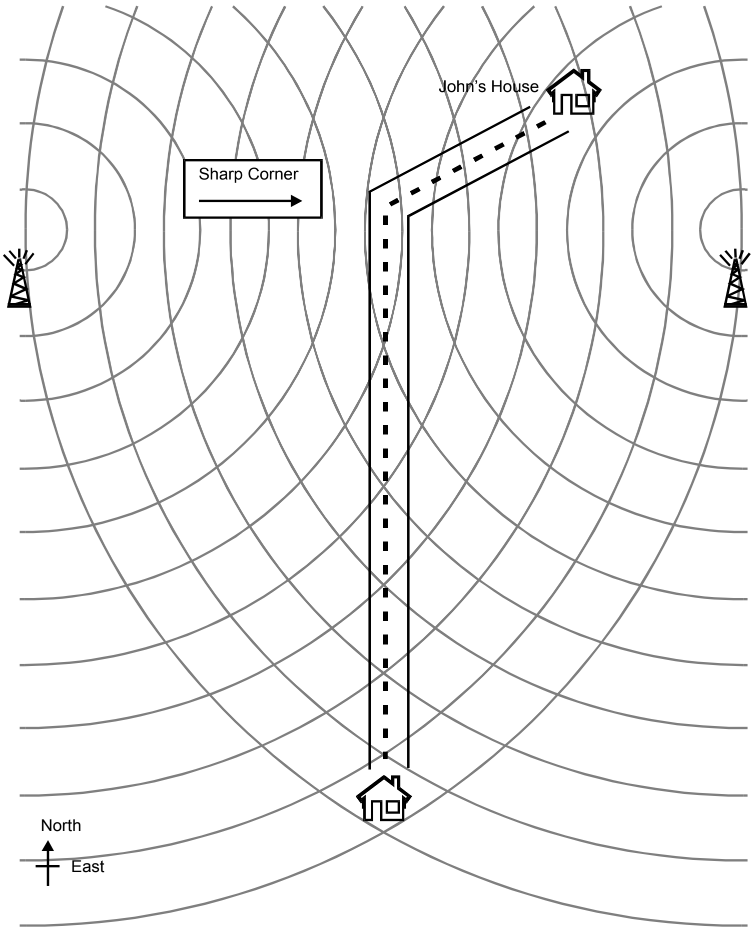
(c) Describe the changes in volume that John would notice during his journey.

Jimmy's house is 40.0km South of the transmitters. The transmitters are 10.0km apart. John's radio is tuned to a station with a wavelength of 200.0m. (1503 kHz)

(d) Show that the first place East of Jimmy's house where the signal is strong for this station is 800m away.

(e) A signal is broadcast at a frequency of 89.2 MHz. Calculate the distance to the first place East of Jimmy's house where it would not be heard.

(f)How far East would Jimmy and John need to go to get another strong signal on both of the stations they like: f_1 = 90.0 MHz and f_2 = 99.0 MHz



Note: the diagram is not drawn to scale.

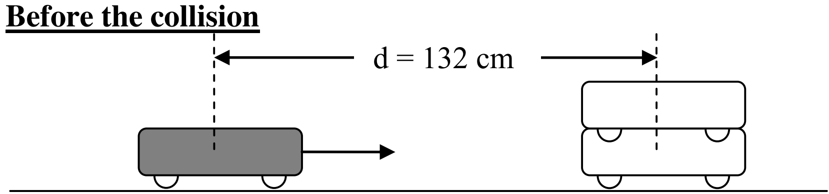
Centre of Mass and Translational Motion Revision Question Set

$F = ma$ $\quad p = mv$ $\quad \Delta p = F\Delta t$ $\quad \Delta E_p = mgh$ $\quad W = Fd$ $\quad E_{K(LIN)} = \frac{1}{2}mv^2$

QUESTION ONE: Bumper-Trolleys

While studying collisions in physics class, Stuart and Julia observed the following collision with very low friction trolleys. Each trolley was the same as the others and they stuck together and moved together after the collision, as shown.

Before the collision



Mass of one trolley = 5.00×10^2 g

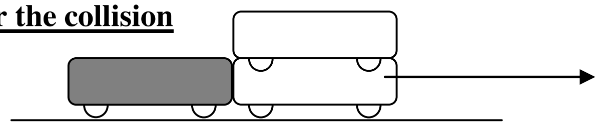
Velocity = 22 cms^{-1}

Two trolleys stacked vertically

Velocity = 0 ms^{-1}

(a) Show that the position of the Centre of Mass (COM) of the trolleys at the instant shown before the collision is 44cm from the centre of the two stacked trolleys.

After the collision



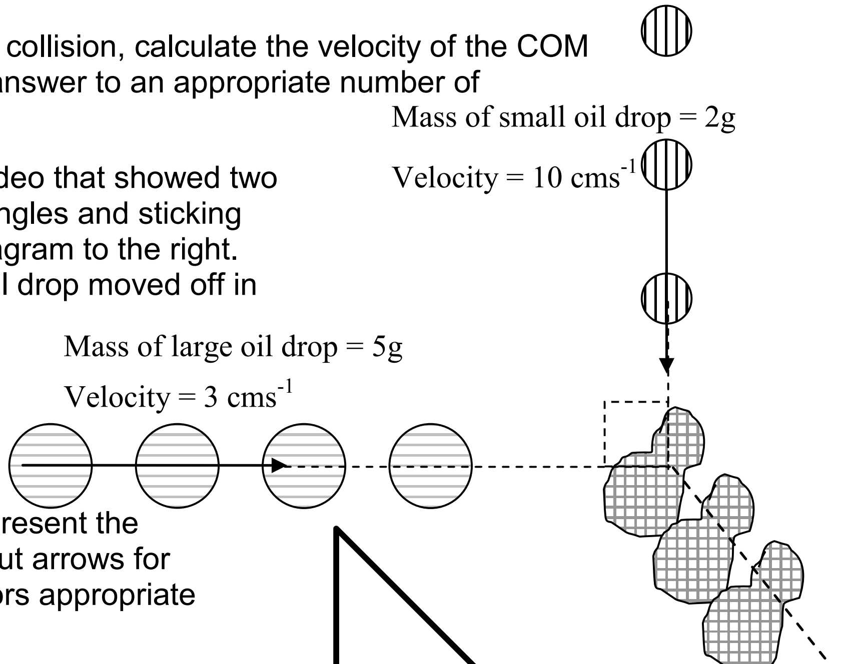
Trolleys stuck together, move with a combined velocity

(b) Show that the momentum of the COM ***before*** the collision is $0.11 kgms^{-1}$.
Explain your reasoning for this answer.

(c) What is the momentum of the COM after the collision?

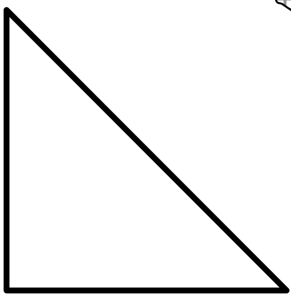
(d) If the trolleys stick together in the collision, calculate the velocity of the COM after the collision. Present your answer to an appropriate number of significant figures.

In another lesson, Stuart watched a video that showed two streams of oil drops colliding at right angles and sticking together. This is represented in the diagram to the right. After sticking together the combined oil drop moved off in the direction shown.



(e) Show that the momentum of the large oil drop is 1.5×10^{-4} $kgms^{-1}$ and of the small one is 2.0×10^{-4} $kgms^{-1}$.

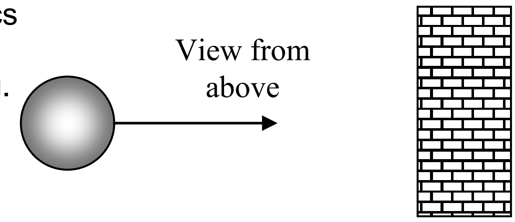
(f) His teacher drew a triangle to represent the vector diagram of the situation. Put arrows for directions and labels on the vectors appropriate for this situation.



(g) By using the vector diagram and calculation, determine the velocity of the centre of mass of the combined oil drop.

QUESTION TWO: Hover-Discs

Terry is playing with a hover-disc on a smooth floor. Hover-discs are small battery powered discs that have a fan and float on a cushion of air. They have a rubber bumper and a mass of 225g. Terry pushes a disc so it collides with a wall at a right angle. The disc comes in at a speed of $0.53 ms^{-1}$ and rebounds at a speed of $0.47 ms^{-1}$. The collision lasts 0.12s.



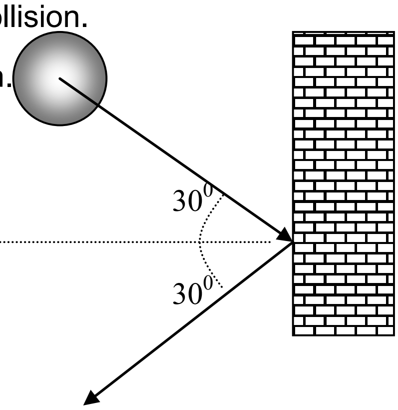
(a) Is this collision elastic or inelastic? Explain your answer.

(b) Explain why the disc's momentum is not conserved during the collision.

(c) Calculate the change in the disc's momentum during the collision.

(d) Calculate the size and direction of the average force the wall exerts on the disc.

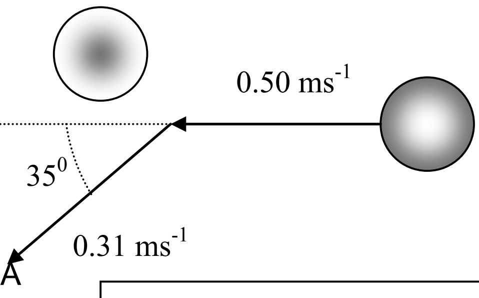
(e) Determine the size and direction of the average force the disc exerts on the wall.



(f) Terry now pushes the disc so it hits the wall at $0.40 ms^{-1}$ and bounces off at $0.40 ms^{-1}$ as shown below.

Draw a vector diagram and use it to calculate the size of the change in velocity. Show the direction of the change in velocity.

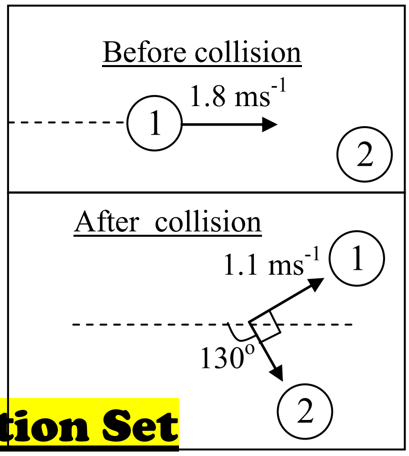
(g) Terry now pushes the disc at $0.50\ ms^{-1}$ so it collides with a second, identical, stationary disc and rebounds as shown below. Using a vector diagram or otherwise, calculate the velocity of the second disc after the collision.



You **may** wish to use the cosine rule $a^2 = b^2 + c^2 - 2bc \cos A$

QUESTION THREE: Air-Hockey

A metal disc of mass 65g is moving at $1.8\ ms^{-1}$ across a frictionless table. It hits another metal disc of the same mass which is stationary. After the collision the first disc moves off at $1.1\ ms^{-1}$ as shown in the diagram. The second disc moves away from it at right angles as shown.



(a) Calculate the **velocity** of the second disc after the collision.

(b) Show whether the collision is elastic or not.

Circular Motion Revision Question Set

$$F = ma \qquad p = mv \qquad \Delta p = F\Delta t$$

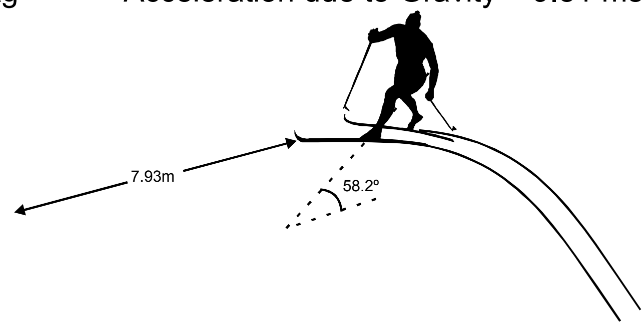
$$\Delta E_p = mgh \qquad W = Fd \qquad E_{K(LIN)} = \tfrac{1}{2}mv^2 \qquad F_g = \frac{GMm}{r^2} \qquad F_c = \frac{mv^2}{r}$$

Mass of Earth = 5.98×10^{24} kg Radius of the earth = 6.37×10^6 m

Universal Gravitational Constant = $6.67 \times 10^{-11}\ Nm^2kg^{-2}$ Acceleration due to Gravity = $9.81\ ms^{-2}$

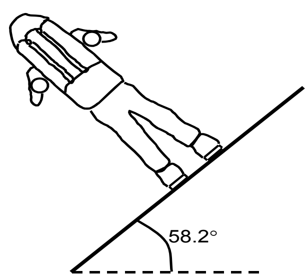
QUESTION ONE: Year 13 Cross-Country Skiing

Jasmine is a cross country skier. On the expedition the group takes a large , icy, banked left hand curve as shown below. The curve has a radius of 7.93 m and her mass, with backpack, is 82.3 kg.



(a) On the diagram draw and label the forces acting on Jasmine as she makes this turn with constant speed. (Assume there is no sideways friction between the skis and the surface of the snow)

(b) Explain why it is possible for Jasmine to travel around the banked curve despite the fact that friction is not present.



(c) By resolving the forces, calculate the snow's force on Jasmine.

(d) Show that the horizontal component of the snow's reaction force on Jasmine is 1300 N.

(e) Calculate the speed at which Jasmine should take this turn. Give your answer to the correct number of significant figures.

(f) Explain (using a diagram if you wish) what would happen to Jasmine if she were to take this turn too slowly?

QUESTION TWO: Hammer Throw

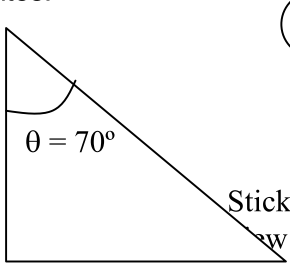
Julia competes in the sport of hammer throwing, as shown in the photo alongside. Julia swings a steel ball on the end of a chain around in a circle then lets it go. A women's hammer is usually 118cm long from the end of the chain to the ball and has a mass of 4.00kg.

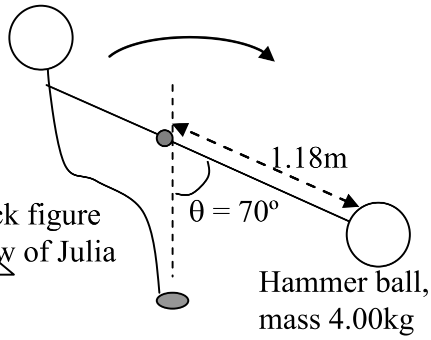
At one point in the ball's swing, it is travelling in a horizontal circle as shown in the diagram below (diagram not to scale):

(a) Explain why a net force must be acting on the Hammer ball?

(b) Show that the acceleration due to gravity on the hammer ball, caused by the attraction of the earth, is $9.83 ms^{-2}$.

(c) The triangle below represents the vector arrangement of the two forces acting on the ball and also shows the net force. Identify and label these three forces on the vector diagram, then calculate the speed of the ball as it rotates.

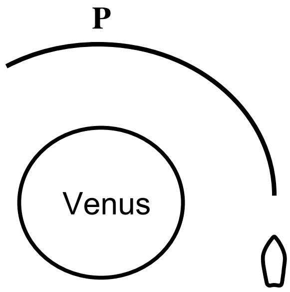




QUESTION THREE: Space Travel

During a space exploration a spacecraft flies past the planet Venus. The diagram below shows the path taken by the spacecraft as it flies past the planet. Use the data given below to answer the following questions.

(a) The point P is 6.682×10^6 m above the centre of the planet Venus. Show that the size of the gravitational force acting on the spacecraft at the instant when it is at P is 3.49×10^5 N.



DATA:
Mass of Venus = 5.41×10^{24} kg
Mass of the spacecraft = 4.32×10^4 kg

(b) State the direction of the force experienced by the spacecraft when it is at the point P.

(c) Calculate the orbital speed of the spacecraft at the point P. State your answer to the correct number of significant figures.

Angular Mechanics Revision Question Set

$d = r\theta$ $\quad v = r\omega$ $\quad a = r\alpha$ $\quad \omega = \frac{\Delta\theta}{\Delta t}$ $\quad \alpha = \frac{\Delta\omega}{\Delta t}$ $\quad \omega = 2\pi f$ $\quad f = \frac{1}{T}$

$E_{K(ROT)} = \frac{1}{2}I\omega^2$ $\quad \omega_f = \omega_i + \alpha t$ $\quad \theta = \frac{(\omega_i + \omega_f)}{2}t$ $\quad \omega_f^2 = \omega_i^2 + 2\alpha\theta$ $\quad \theta = \omega_i t + \frac{1}{2}\alpha t^2$

$\tau = I\alpha$ $\quad \tau = Fr$ $\quad L = mvr$ $\quad L = I\omega$

QUESTION ONE: Ice Skating

Stuart is an ice skater who does figure skating. In one particular move he goes into a spin with an initial angular velocity of 3.4 rad s^{-1}. At this instant he is upright with his arms and one leg stretched out, and has a rotational inertia about his centre of mass of 10.8 kg m^2. He immediately pulls his arms and leg in close to his body. This reduces his rotational inertia to 4.5 kg m^2.

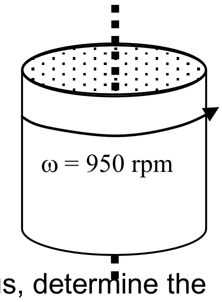
(a) Calculate the angular momentum of Stuart while his arms and leg are sticking out. Give a unit with your answer.

(b) Explain why his rotational inertia decreases as he pulls his arms and leg in close to his body.

(c) Calculate Stuart's initial rotational kinetic energy (when his arms and leg are sticking out).

(d) After pulling his arms and leg in, Stuart finds his rotational kinetic energy has increased. Explain where this extra energy has come from.

After Stuart's figure skating, his mother washes his skating costume in the automatic washing machine. The washing machine is essentially a vertical cylinder that spins on its vertical axis (see diagram) to a high velocity and uses the centrifugal effect to remove water from the washing. A typical machine drum spins to a rate of 950 rpm (revs per minute) from an initial zero speed.

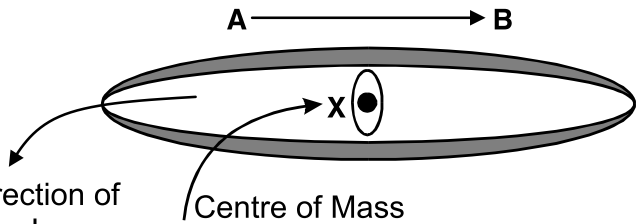


(e) Show that 950 rpm is 99.5 $rads^{-1}$.

(f) The drum takes 5s to reach this speed. Using sensible estimates of drum mass and radius, determine the net Torque needed by the washing machine motor to do this. (Assume $I = mr^2$)

QUESTION TWO: Canoe Polo

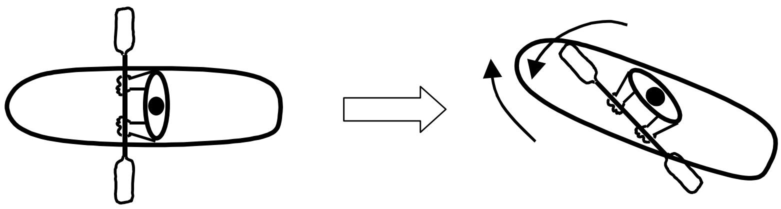
This is a game played in a swimming pool with 2 teams in small kayaks. These kayaks are highly manoeuvrable but quite unstable. Players paddle around the pool after a polo ball, which they pass between team mates.



Alexey's first time in a kayak created some problems for him. He found that as he took right hand paddle strokes from A to B he would head left, as shown below.

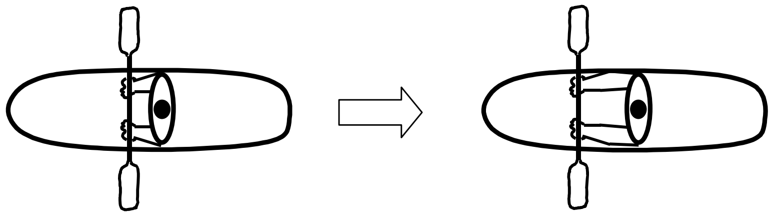
(a) Explain why this is happening.

As Alexey gained experience playing canoe polo he found he could turn the kayak without dipping his paddle in the water but just a twist of his hips instead.

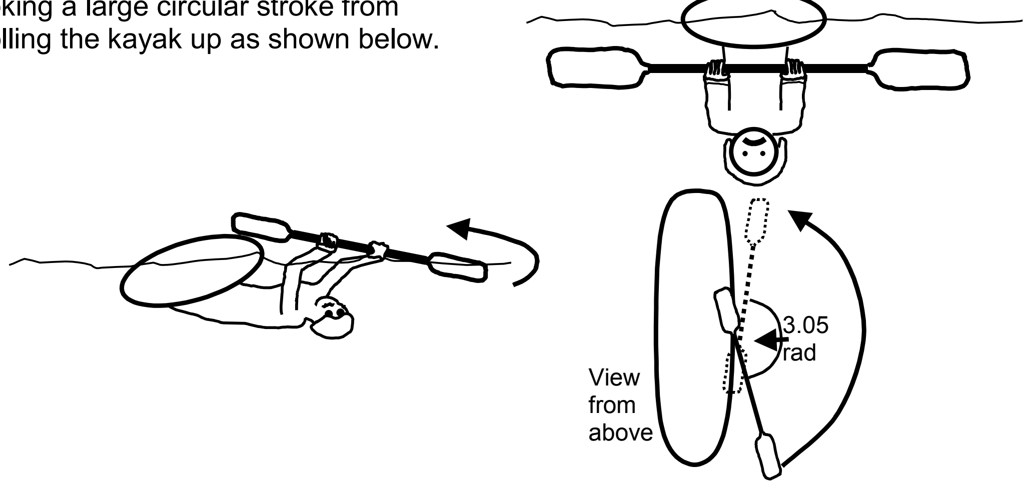


(b) Explain why he did not need to use his paddle.

(c) Explain what effect he would have on the turn of his kayak if he held his paddle further from his body as shown below.



Alexey soon found that his kayak would easily turn over. He had to learn a new skill – self recovery (called an Eskimo roll). This involves stroking a large circular stroke from forward to back and rolling the kayak up as shown below.



Alexey would turn this stroke through 3.05 rad in 1.03 s.

(d) Show that the angular acceleration of this paddle stroke is 5.74 $rads^{-2}$.

Simple Harmonic Motion Revision Question Set

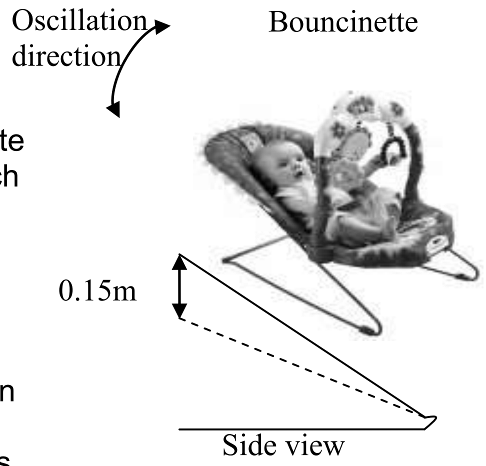
$a = -\omega^2 y$ $\quad F = -ky$ $\quad T = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = 2\pi\sqrt{\frac{m}{k}}$ $\quad E = \frac{1}{2}ky^2$

$y = A\sin\omega t$ $\quad v = A\omega\cos\omega t$ $\quad a = -A\omega^2\sin\omega t$

$y = A\cos\omega t$ $\quad v = -A\omega\sin\omega t$ $\quad a = -A\omega^2\cos\omega t$

<u>QUESTION ONE:</u> Bouncin' Baby

Julia has a baby brother whom she looks after for her mother. She put him in his bouncinette, (a bouncy lie-in seat) as shown in the photo. Julia notices that the high end of the bouncer deflects downwards by 0.15 m when the baby is placed in it. The bouncinette can be thought of as a spring, so it will have a spring constant which can be calculated. Her Baby brother has a mass of 6.5 kg.



(a) Show that the bouncinette's spring constant is 420Nm^{-1}. (2 significant figures)

As the baby moves he causes the bouncinette to oscillate up and down. Over small angles the end of the bouncer appears to move in simple harmonic motion.

(b) Show that the period of the baby's oscillatory motion is 0.78s.

(c) What is the angular frequency (ϖ) of the baby's motion?

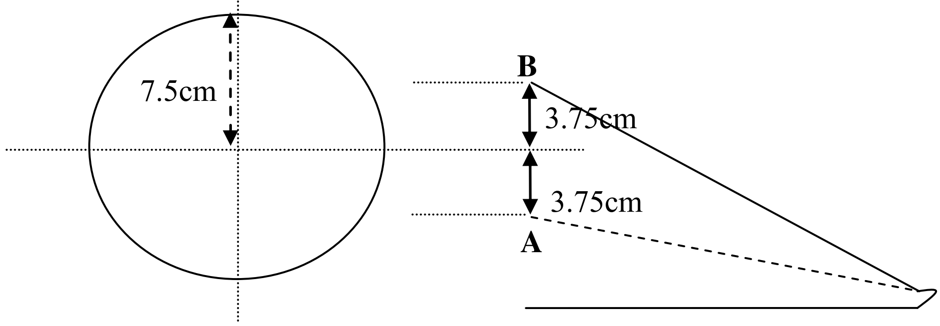
Julia pushes the bouncinette down with the baby in it.

(d) Calculate the maximum acceleration the baby experiences if Julia pushes the bouncinette down 7.5 cm.

(e) Where in the motion does this maximum acceleration occur?

(f) Explain, in terms of accelerations, what could happen to the baby if the bouncinette was pushed down further 17 cm and released.

(g) Using the reference circle below or otherwise, show that the time it takes for the bouncinette to go from position A in its motion (3.75 cm below the resting point) to position B in its motion (3.75 cm above the resting point) is 0.13 s. The maximum oscillation amplitude (A) for the motion is 7.5 cm (radius of the reference circle). The period of oscillation is 0.78 s.

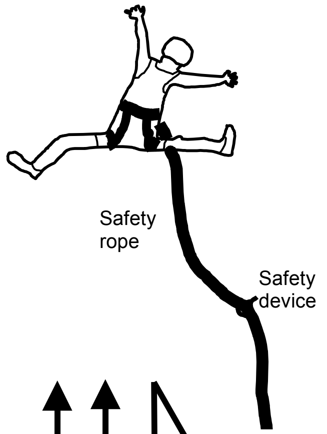


QUESTION TWO: Rock Climbing

Pascal is lead climbing as shown below. This means he climbs up pulling a safety rope behind him. Someone below holds this rope. He puts safety devices into the rock face as he climbs up to hold the rope.

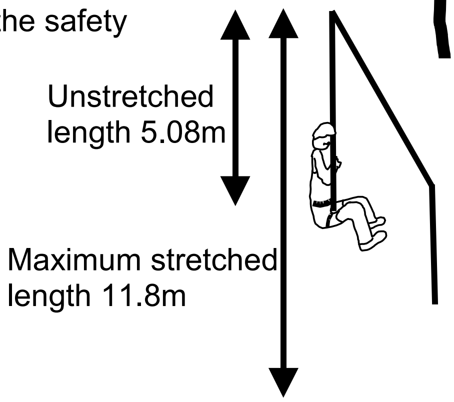
He falls off but is held by his safety rope. At a length 5.08 m below the highest safety device the rope begins to extend.

The rope has a spring constant of 208 Nm^{-1}. Pascal's mass is 74.4 kg.



(a) Pascal bounces up and down on the end of the rope until he comes to rest. Calculate the rope's extension with Pascal hanging on the end.

When Pascal first fell the rope stretched until it was 11.8 m below the safety device. He then oscillated vertically with Simple Harmonic Motion.



(b) What is the length from the safety device to the centre of the oscillation?

(c) Show that the period of oscillation of Pascal on the rope is 3.76 s.

(d) At one stage of the oscillations the amplitude was 3.21m. Calculate the maximum acceleration at this stage.

(e) Where does this maximum acceleration occur?

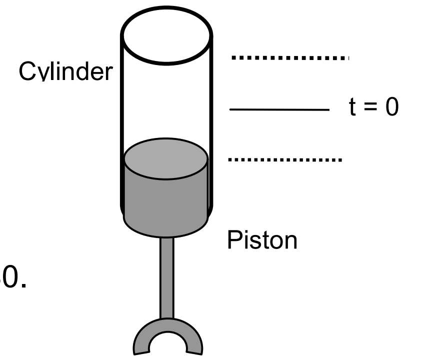
(f) By comparing the acceleration in part (e) to the acceleration due to gravity make a judgement on how uncomfortable Pascal would find this.

The rope's designers have included a damping feature in its structure. It damps off the motion within 5 oscillations.

(g) What does damping mean and what must the rope's structure do to the simple harmonic system to achieve this?

QUESTION THREE: Car Piston

In a car engine the piston moves up and down in the cylinder to power the engine. The diagram below shows the piston-cylinder assembly. The motion of the piston in a car engine is approximately simple harmonic. The amplitude of the piston is 0.055m and its frequency of oscillation is 140Hz.



(a) Explain the meaning of the term "simple harmonic motion".

(b) Show that the value of the angular frequency for the piston is 880. State the appropriate SI unit with your unrounded answer.

(c) Calculate the total distance travelled by the piston in 1 complete cycle.

(d) Calculate the maximum speed of the piston.

(e) Sketch the velocity-time graph of the piston's motion for one complete cycle. Assume t=0 when the piston is at the equilibrium position and moving upwards. Label any available values for time and velocity.

(f) Calculate the maximum acceleration of the piston.

(g) Where does the maximum acceleration take place during the motion of the piston? Give a reason for your answer.

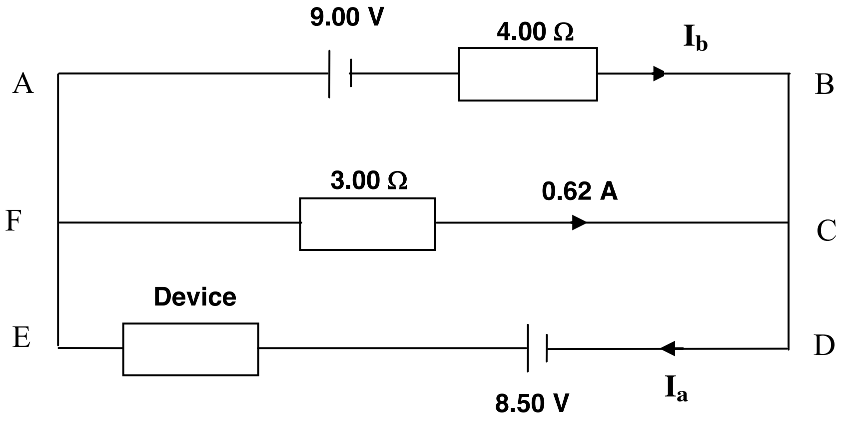
Internal Resistance & Kirchoff Revision Question Set

$V = IR$

QUESTION ONE: Old 9V Batteries

Stuart and Julia set up a circuit to see if connecting two batteries in parallel would make a certain device work better than it did with only one battery. They used two 9V batteries.

One of the batteries came from a new packet and the other was one that had been used already. Before they placed them in the circuit shown below they measured their voltages using a digital multi-meter and found them to be 9.4V (top battery) and 8.8V (bottom battery) respectively.



However, on placing them in the circuit the voltmeter readings across the batteries became those shown on the diagram.

They also measured the current flowing in one of the arms of the circuit and found it to be 0.62A, flowing in the direction indicated.

(a) Explain why Kirchoff's loop equation for the top loop can be written as $9.00 - 1.86 + 4.00I_b = 0$

(b) Use this to obtain the current, Ib, flowing in the top arm of the circuit and state the direction it is flowing in, (A to B or B to A).

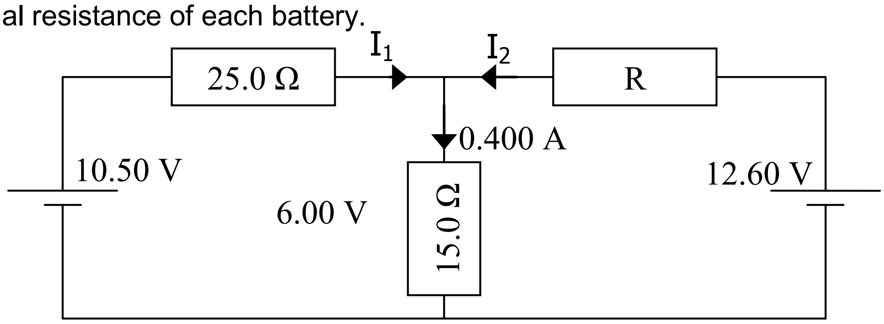
(c) Calculate the current, Ia, flowing in the lower arm of the circuit.
Find the resistance of the device in Ohms.

(e) The batteries have internal resistance. Why does this affect the size of the measured voltage when a current is flowing?

(f) Combine information to find the internal resistance of each battery.

QUESTION TWO: KirchHoff's Rules

The voltage across the 15.0 Ω resistor is 6.00 V.



(a) State Kirchhoff's Current Rule.

(b) State the basic physical principle upon which it is based.

(c) Show that the voltage across the 25.0 Ω resistor is 4.50 V.

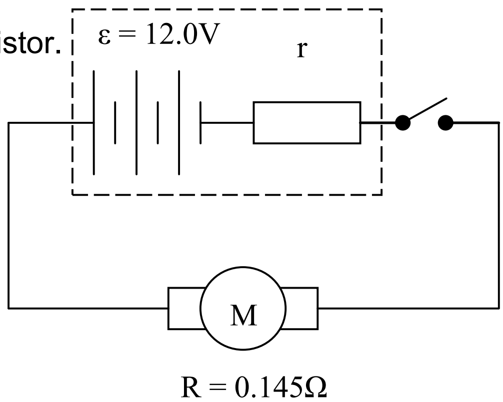
(d) Determine the value of I_1 the current through the 25.0 Ω resistor.

(e) Determine the value of I_2 the current through the resistor, R.

(f) Determine the value of the resistance, R.

QUESTION THREE: 12V Battery

The electric starter motor for a car is connected to a 12V battery as shown below. The motor (M), has a resistance of 0.145 Ω and draws a current of 50.0 A when the switch is closed.

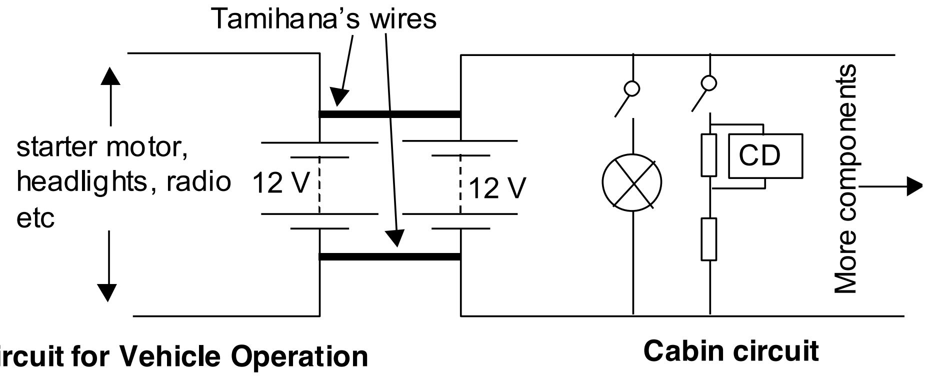


(a) Determine the internal resistance, r, of the battery.

(b) Explain how the terminal voltage of the battery changes as the internal resistance, r, increases.

QUESTION FOUR: Car Batteries

Joanne and Tamihana have a camper van that uses two normal car batteries. They are both fixed in the engine bay. Normally one is used for vehicle operations and the other for cabin appliances (CD player, lights, etc).



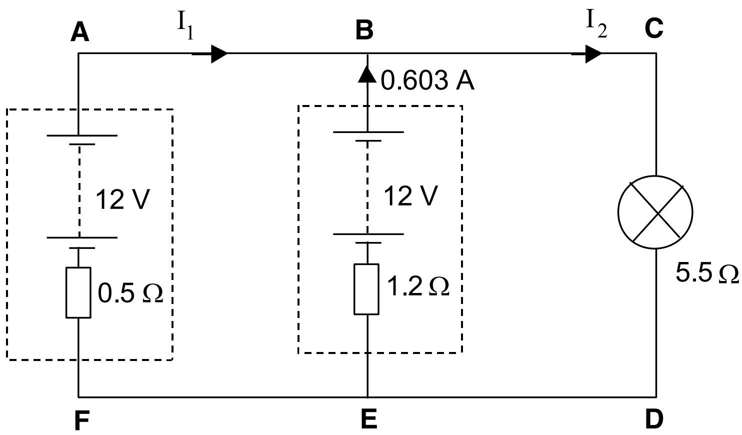
After a long drive, both batteries are recharged. Tamihana wants to connect both batteries together to improve the operation of the cabin lights. The diagram below shows how he did this.

The diagram shows the circuit in more detail.
Use it to answer question (a) and question (b).

(a) Use Kirchoff's Voltage Law in the loop BCDEB to show that the current I_2 = 2.05A.

(b) Use Kirchoff's Current Law to find the current I_1.

(c) Describe a measurable change that occurs inside the battery when it goes flat.



Capacitors (DC) Revision Question Set

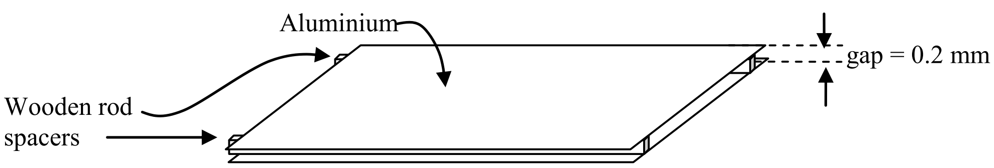
$V = Ed$ $\Delta E = Vq$ $E_{cap} = \frac{1}{2}QV$ $Q = CV$ $P = VI$ **V = IR** $\tau = RC$

$C_T = C_1 + C_2 + C_3 + \ldots$ $\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ $C = \frac{\varepsilon_o \varepsilon_r A}{d}$ $R_T = R_1 + R_2 + \ldots$ $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

$\varepsilon_o = 8.85 \times 10^{-12}$ Fm^{-1} $\varepsilon_{Air} = 1$

QUESTION ONE: Capacitors

While investigating an old radio, Stuart and Julia found that it contained a large capacitor. They measured its capacitance with a digital multi-meter and found it was 65μF. The maximum voltage rating of the capacitor was 15V. They decided to make a model of the capacitor using aluminium plates. The model is arranged as shown below.



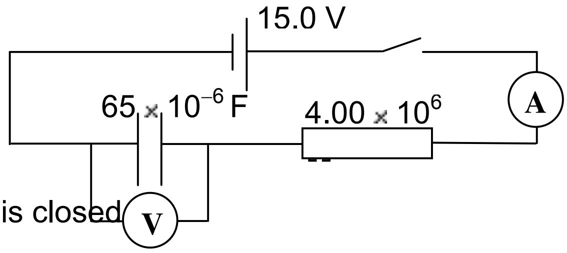
(a) Show that the area of the Aluminium that would be needed to achieve a capacitance of 65μF is 1470m^2.

This is large area (a square of size approximately 38m x 38m). One way to minimise the size of the plates is to place a non-conducting material, a dielectric, between the two plates to increase the capacitance.

(b) State another way this capacitance could be achieved in order to make the physical size of this capacitor significantly smaller.

(c) Stuart and Julia want the area of their capacitor plates to be 10cm x 10cm. What is the size of the dielectric constant that is needed to make a 65μF capacitor of this area with an 0.2mm separation between the plates?

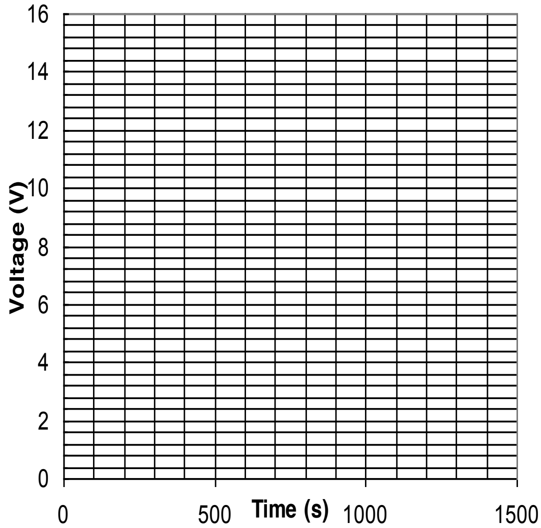
In their investigation of the capacitor, Stuart and Julia connected it into a circuit as shown. When they closed the switch they noticed that the readings on the ammeter and voltmeter changed in a steady and smooth fashion.



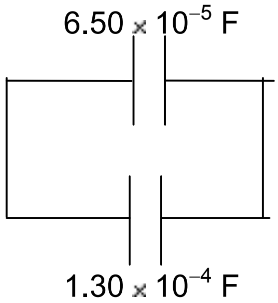
(d) Calculate the current that starts to flow as the switch is closed

(e) On the axes on the next page, sketch a graph to show how the voltage across the capacitor plates changed once the switch was closed. Include at least one specific voltage value reached and the time at which it was reached.

(f) Calculate the charge separated on the plates of the capacitor (or 'stored' as it commonly referred to) when it is fully charged to 15V. Write your answer to an appropriate number of significant figures and include an appropriate unit.



The fully charged 6.50×10^{-5} F (65μF) capacitor is removed from the circuit and is now connected in a loop with an uncharged 1.30×10^{-4} F (130μF) capacitor as shown in the diagram

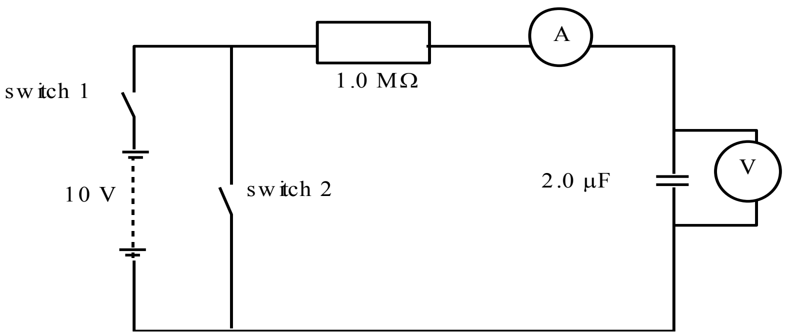


(g) Calculate the energy that is now stored in the 65 μF capacitor

QUESTION TWO: More Capacitors

Owen and Adele are investigating the properties of capacitors.

To investigate a capacitor they set up the following circuit.



(a) Explain the general function of capacitors.

(b) Explain the function of the dielectric in capacitor construction.

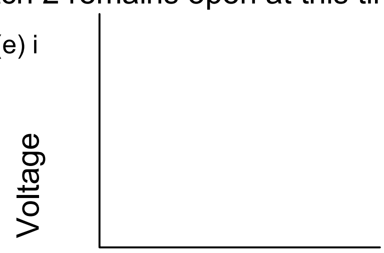
(c) Describe another way to increase the capacitance of a capacitor.

(d) Calculate the time constant for this circuit.

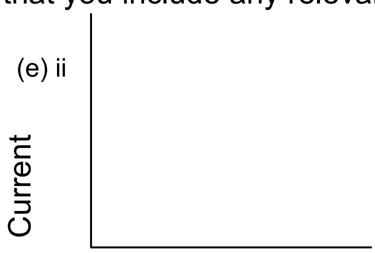
Adele closed Switch 1 and took readings from the ammeter and voltmeter over time.

(e) Using the axes below, show how the voltage and current change over time after switch 1 is closed. Switch 2 remains open at this time. Make sure that you include any relevant numerical values.

(e) i

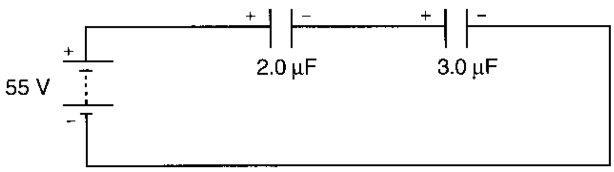


(e) ii



(f) Calculate the energy stored in the capacitor when it is fully charged.

Adele and Owen build another circuit, this time with two capacitors, one a 2.0μF capacitor and the other a 3.0μF capacitor as shown in the diagram below.



(g) Show that the total capacitance of the pair of capacitors in series 1.2μF.

(h) Calculate the charge on the 2.0μF capacitors when wired in this configuration.

(i) Calculate the voltage across the 2.0μF capacitor, when wired in this configuration.

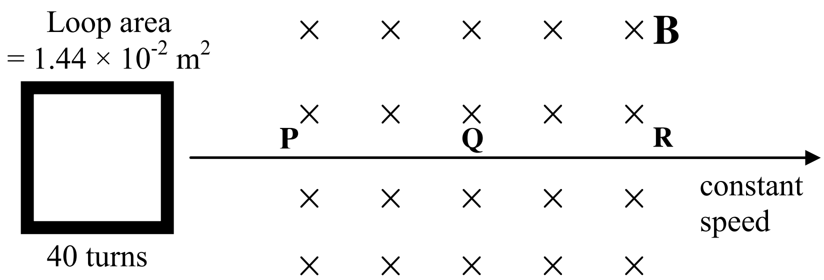
Induction of Voltage Revision Question Set

$\phi = BA$ $\varepsilon = -L\frac{\Delta I}{\Delta t}$ $\varepsilon = -\frac{\Delta \phi}{\Delta t}$ $\varepsilon \ -M\frac{\Delta I}{\Delta t}$ $\frac{N_p}{N_s} = \frac{V_p}{V_s}$ $E = \frac{1}{2}LI^2$ $\tau = \frac{L}{R}$

QUESTION ONE:

A square loop of wire with 40 turns and area of $1.44 \times 10^{-2} m^2$ moves through an area of uniform magnetic field at a constant speed as shown.

As the loop enters the magnetic field at point P, a voltage of 1.30V is induced in the coil. It takes the loop 1.00×10^{-2} s to completely enter the field.



(a) State Lenz's law.

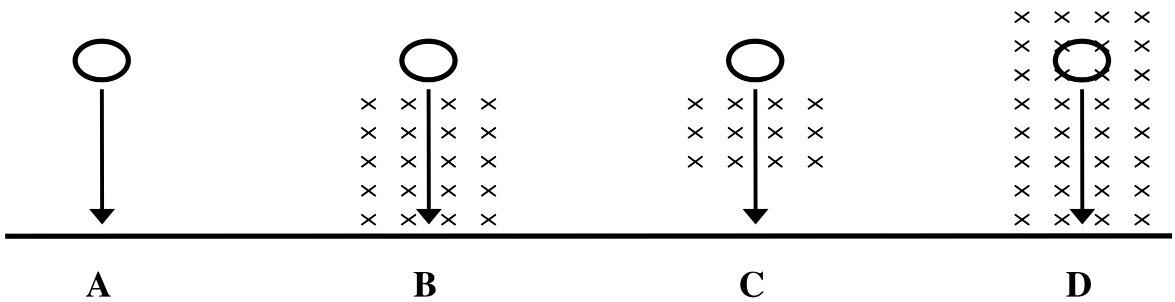
(b) State the fundamental physical principle that Lenz's Law is based on.

(c) Indicate which direction the current in the loop flows as it enters the field at point P. Give reasons for your answer.

(d) Determine the value of B, the magnetic flux density (magnetic field strength). Give a unit with your answer.

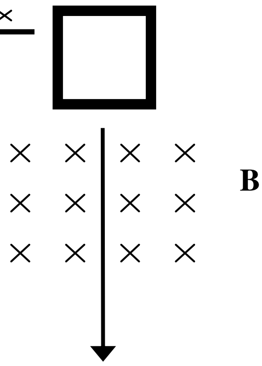
(e) Determine the induced voltage as the loop moves through the field at point Q.

(f) Four identical loops of wire are dropped from the same height at the same time. However they fall through different magnetic fields. (All magnetic fields are uniform and the same strength).

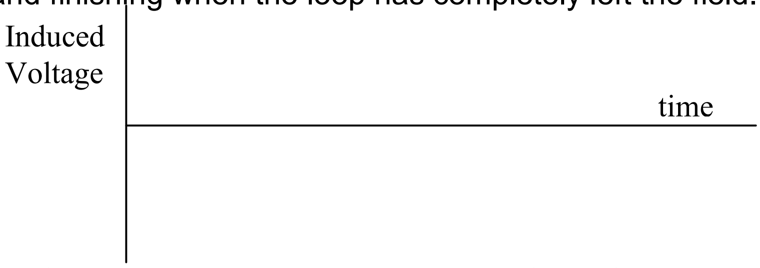


State the order in which the loops hit the floor. Give reasons for your answer.

(g) A square loop of wire is dropped through a region of uniform magnetic field as shown.

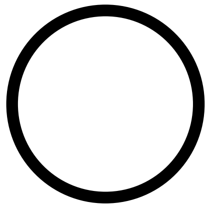


On the axes below, sketch a graph of induced voltage against time, starting when the loop first starts entering the field (t = 0) and finishing when the loop has completely left the field.



QUESTION TWO:

A very small inductor loop of diameter 1.05cm and resistance of 0.15Ω shown is initially threaded by a magnetic field into the page of 2.4×10^{-2}T. This magnetic field drops away to zero in 3.5 s.



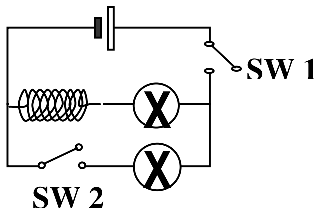
(a) Calculate the total flux through the coil initially.

(b) Calculate the induced Emf in the loop as the field dies away.

(c) Calculate the magnitude of the induced current and give its direction. Explain your reasoning.

QUESTION THREE:

A circuit contains a large inductor and two light-bulbs as shown.



(a) SW2 is closed. When SW1 is closed, the light bulb in series with the inductor lights up more slowly than the other light-bulb. Explain this.

(b) When an equivalent AC supply is applied to the circuit instead of DC, the upper light-bulb does not light up but the lower one does. Explain this.

QUESTION FOUR:

An inductor of 10 H is connected into a circuit and has a DC current of 3 A flowing through it. The circuit is switched off, and as the switch is opened, a spark is seen to jump across the points of the switch.

(a) Explain why this spark is produced.

(b) Calculate the induced Emf in the coil (producing the spark) when the switch is opened, if the 3 A current reduced to zero in 0.12 s

(c) Calculate the energy stored in the inductor before it was switched off.

(d) When the switch is opened, an induced current tries to flow in the coil. State the direction of this induced current relative to the original current direction. Explain your thinking.

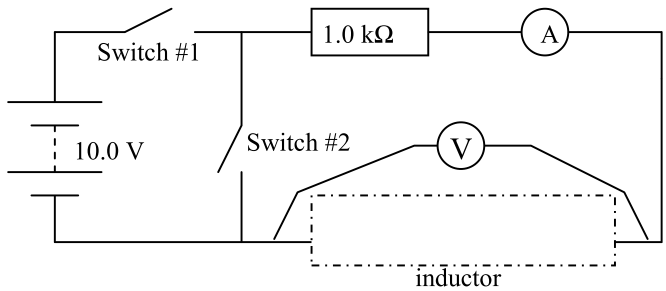
Inductors & Transformers Revision Question Set

$\phi = BA$ $\quad \varepsilon = -L\frac{\Delta I}{\Delta t}$ $\quad \varepsilon = -\frac{\Delta\phi}{\Delta t}$ $\quad \varepsilon \; -M\frac{\Delta I}{\Delta t}$ $\quad \frac{N_p}{N_s} = \frac{V_p}{V_s}$ $\quad E = \frac{1}{2}LI^2$ $\quad \tau = \frac{L}{R}$

QUESTION ONE:

Owen and Adele are investigating the properties of capacitors and inductors. They begin their investigation looking at inductors.

To investigate an inductor they set up the circuit shown:



(a) Draw the circuit symbol for a realistic inductor that would be in the gap in the circuit diagram.

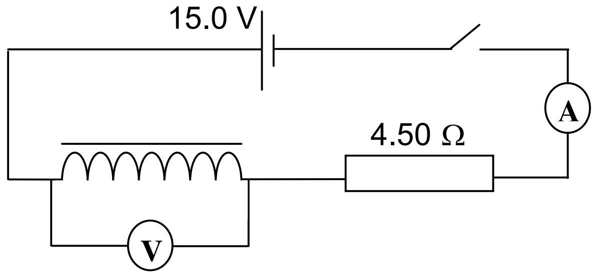
(b) Explain the function of an inductor in a DC circuit.

Owen reads that the inductor has an inductance of 35mH and a resistance of 55 Ω.
He closed switch 1 and took readings from the ammeter and voltmeter over time.

(c) Sketch TWO graphs to show how the current and voltage change over time after switch 1 is closed. Switch 2 remains opens at this time. Include any relevant numerical values on these sketch graphs.

QUESTION TWO: the radio Inductor

While examining the old radio, Stuart and Julia found an inductor, a coil of insulated copper wire wound around a core of iron. They decided to investigate its properties by placing it in the circuit shown below. When they closed the switch, they followed the change in current and voltage in the circuit, using the meters shown.



From their readings they estimate that when the switch was first closed the current's value initially changed at 45 As^{-1}. Assume the inductor has negligible resistance.

(a) What was the initial voltage reading on the voltmeter?

(b) Calculate the self inductance of the coil and give it the appropriate number of significant figures with the correct unit.

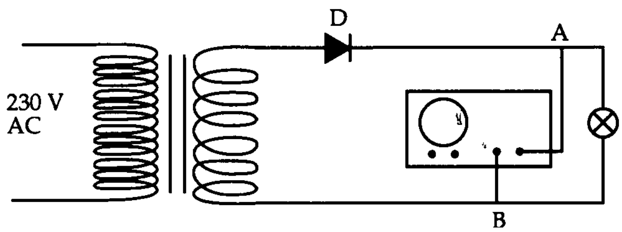
After taking all their measurements, Julia flicked the switch back to the off position. As she did so, she saw a spark jump from one side of the switch terminals to the other.

(c) Explain the reason for this spark.

(d) Julia concluded that there was energy stored in the inductor. Calculate how much energy the inductor was storing.

QUESTION THREE

Many electronic devices, such as computers, need a constant DC power supply of 5 volts but the mains voltage is 230 volts AC. A circuit to convert 230 volts AC to 5 volts DC might be constructed as shown. D is a diode which allows current to pass in one direction only.



(a) Explain the function of the transformer and how it works.

(b) There are 1250 turns of wire in the primary coil. Calculate the number of turns in the secondary coil.

(c) Explain why the circuit above is not as efficient as it could be and what could be done to increase the efficiency of the circuit.

The reading of 230 V for the primary coil is not the true value for the voltage across the coil because the voltage is continuously changing.

(d) What is the peak voltage across the coil?

QUESTION FOUR

Two coils are wound over each other on a soft iron core. The primary coil has 500 turns and the secondary has 15000 turns.

(a) If the AC voltage in the primary is 1.5 V (RMS), show that the voltage in the secondary coil is 45V.

(b) If the secondary coil is connected to a circuit with a resistance of 470 Ohms, calculate the current in the secondary coil.

(c) Calculate the current in the primary coil that will produce the results described in (b).

(d) The primary coil is now connected to a DC supply and switched on. The current in it reaches a value of 220 mA after 0.8 s. If the Voltage induced in the secondary coil during this time is 23 V, calculate the mutual inductance of the arrangement.

(e) Explain why the two coils in a transformer are not wound on a single piece of iron. In your answer suggest a design for the iron core that will allow for greatest efficiency.

(f) Another transformer has a mutual inductance of 0.8 H. The primary coil has 700 turns and the secondary has 14000 turns.

(i) The current in the primary is seen to change smoothly from 0.5 A to 3.3 A in 3 s. What voltage is induced in the secondary coil during this time?

(ii) An alternating voltage of 12 V is applied to the primary coil and a current of 1.23 A flows in it. What is the voltage and current induced in the secondary?

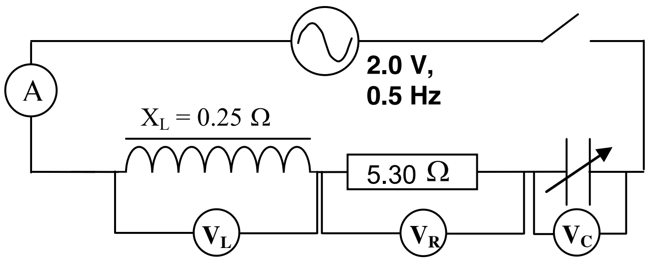
Alternating Current Revision Question Set

$I = I_{MAX} \sin\omega t$ $V = V_{MAX} \sin\omega t$ $I_{MAX} = \sqrt{2} I_{rms}$ $V_{MAX} = \sqrt{2} V_{rms}$ $X_C = \frac{1}{\omega C}$ $X_L = \omega L$

$V = IZ$ $\omega = 2\pi f$ $f = \frac{1}{T}$

QUESTION ONE: LRC Circuit

Stuart and Julia noticed that in the radio there was a capacitor and inductor connected to a resistor in series as shown in the diagram. The arrow through the capacitor symbol means its capacitance can be changed. The radio was designed to operate from a 2.0 V A.C. power supply. The inductor is initially assumed to have negligible resistance.



They placed in the circuit three A.C. digital voltmeters as shown, 1 across each of the elements in the circuit, and also added a digital A.C. ammeter as shown.

At first Stuart and Julia investigated this circuit using low frequency A.C., f = 0.5Hz.

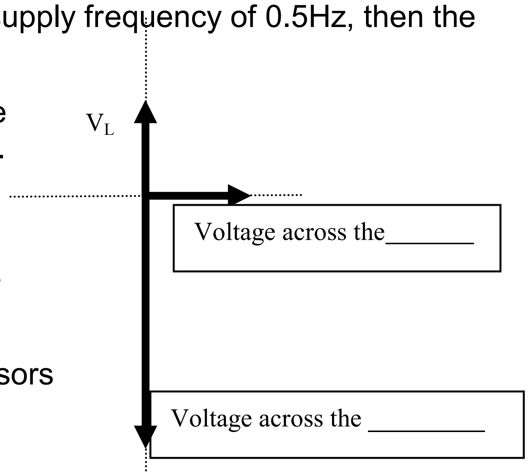
(a) Calculate the peak output voltage from the AC source.

(b) Show that if the inductor has a reactance of 0.25 Ω at a supply frequency of 0.5Hz, then the inductance value is 0.080H.

(c) The capacitor is initially adjusted so that the current value reads 0.16 A. Calculate the total impedance of the circuit.

(d) On the phasor diagram, the phasor representing the voltage across the inductor has been labelled. Label the remaining phasors that represent the voltages across the resistor and the capacitor.

(e) On the same phasor diagram above, mark and label phasors representing the voltage and current of the 2.0V supply voltage.



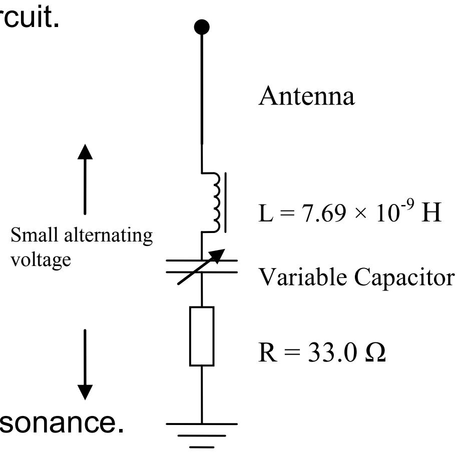
Julia now slowly raises the frequency of the supply voltage without changing the amplitude. As she does so she notices the current on the ammeter rises to a maximum value when the frequency equals 3.32Hz, and then drops away. This effect is known as resonance.

(f) What is the total impedance of the circuit at resonance?

(g) Calculate the voltage across the capacitor at resonance if the inductor has the value 0.080 H and the 5.3 Ω resistance value includes all the resistance in the circuit.

QUESTION TWO: radio tuning circuit

A simple radio tuning circuit consists of a resistor, a variable capacitor and an inductor connected in series (an LCR circuit). The variable capacitor can be adjusted to tune the circuit to different frequencies.



(a) The radio waves received by the antenna act as an AC power supply. Explain why a voltage will be induced across the inductor.

The capacitance of the capacitor is altered until resonance occurs.

(b) What happens to the current in the LCR circuit when it is at resonance.

(c) Make a complete the voltage phasor diagram to show the inductor voltage, V_L, and capacitor voltage, V_C, and resistor voltage, V_R, when the circuit is at resonance.

(d) Calculate the reactance of the inductor ($L = 7.69 \times 10^{-9}$ H) at a frequency of 9.0×10^7 Hz. Give your answer to the correct number of significant figures.

(e) Determine the impedance of the circuit at resonance.

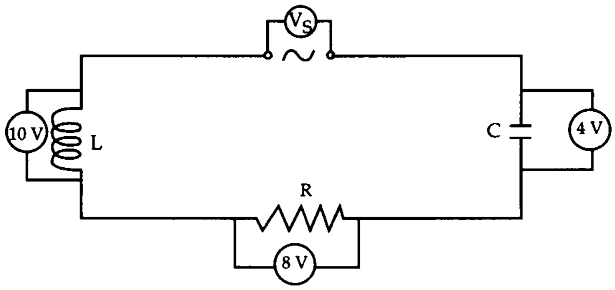
(f) Using the physical properties of capacitors, explain why the resonant frequency of the circuit decreases when the capacitance is increased.

(g) Determine the resonant frequency of the circuit when the capacitance is at its maximum value of 416pF.

QUESTION THREE: Another LRC Circuit

AC voltage measurements made across the components of the circuit as shown.

When the power supply voltage is measured it is found to be nowhere near 22 volts (the algebraic sum of the voltages across the components).



(a) Sketch a phasor diagram of the three voltages to show why this is so.

An ammeter was placed into the circuit and the current was found to be 0.50 A.

(b) Calculate the impedance of the circuit.

2013 L3 Physics External Exam Material Summation

(from NZQA NCEA final standard versions as of Nov 21st 2012)

P3.3 waves (AS 91523) 4 credits

- Interference (quantitative) of electromagnetic and sound waves,
- including multi-slit interference and diffraction gratings;
- standing waves in strings and pipes;
- harmonics;
- resonance;
- beats;
- Doppler Effect (stationary observer for mechanical waves)

Relationships: $d\sin\theta = n\lambda$ $\quad n\lambda = \frac{dx}{L}$ $\quad f' = f\frac{v_w}{v_w \pm v_s}$

P3.4 mechanics (AS 91524) 6 credits

***Translational & Circular Motion*:**

- Centre of mass (1 and 2 dimensions);
- conservation of momentum and impulse (2 dimensions only)
- Velocity and acceleration of, and resultant force on, objects moving in a circle under the influence of 2 or more forces,
- Newton's Law of gravitation, satellite motion

***Rotational Motion*:**

- Rotational motion with constant angular acceleration;
- torque;
- rotational inertia;
- conservation of angular momentum;
- conservation of energy

***Oscillating Systems*:**

- The conditions for Simple Harmonic Motion,
- angular frequency,
- variation of displacement, velocity and acceleration with time,
- phasor diagrams,
- reference circles,
- damped and driven systems,
- resonance,
- conservation of energy

Relationships: $x_{COM} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$ $\quad d = r\theta$ $\quad v = r\omega$ $\quad a = r\alpha$ $\quad \omega = \frac{\Delta\theta}{\Delta t}$ $\quad \alpha = \frac{\Delta\omega}{\Delta t}$ $\quad \omega = 2\pi f$

$E_{K(ROT)} = \frac{1}{2}I\omega^2$ $\quad \omega_f = \omega_i + \alpha t$ $\quad \theta = \frac{(\omega_i + \omega_f)}{2}t$ $\quad \omega_f^{\,2} = \omega_i^{\,2} + 2\alpha\theta$ $\quad \theta = \omega_i t + \frac{1}{2}\alpha t^2$ $\quad \tau = I\alpha$

$L = mvr$ $\quad L = I\omega$ $\quad F_g = \frac{GMm}{r^2}$ $\quad T = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = 2\pi\sqrt{\frac{m}{k}}$ $\quad y = A\sin\omega t$ $\quad v = A\omega\cos\omega t$

$a = -A\omega^2\sin\omega t$ $\quad y = A\cos\omega t$ $\quad v = -A\omega\sin\omega t$ $\quad a = -A\omega^2\cos\omega t$ $\quad a = -\omega^2 y$

P3.6 electrical systems (AS 90526) 6 credits

***Resistors & Capacitors in DC circuits*:**

- Internal resistance;
- simple application of Kirchhoff's Laws
- Parallel plate capacitor;
- capacitance;
- dielectrics;
- series and parallel capacitors;
- charge/time, voltage/time and current/time graphs for a capacitor;
- time constant;
- energy stored in a capacitor

***Inductors in DC circuits*:**

- Magnetic flux;
- magnetic flux density;
- Faraday's Law; Lenz's Law;
- the inductor;
- voltage/time and current/time graphs for an inductor;
- time constant;
- self inductance;
- energy stored in an inductor;
- the transformer

***AC circuits*:**

- The comparison of the energy dissipation in a resistor carrying direct current and alternating current;
- peak and rms voltage and current;
- voltage and current and their phase relationship in LR and CR series circuits;
- phasor diagrams;
- reactance and impedance and their frequency dependence in a series circuit;
- resonance in LCR circuits

Relationships:

$E = \frac{1}{2}QV$ $\quad Q = CV$ $\quad C = \frac{\varepsilon_o\varepsilon_r A}{d}$ $\quad C_T = C_1 + C_2 + \ldots$ $\quad \frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$ $\quad \tau = RC$ $\quad \phi = BA$

$\varepsilon = -L\frac{\Delta I}{\Delta t}$ $\quad \varepsilon = -\frac{\Delta\phi}{\Delta t}$ $\quad \frac{N_p}{N_s} = \frac{V_p}{V_s}$ $\quad E = \frac{1}{2}LI^2$ $\quad \tau = \frac{L}{R}$ $\quad I = I_{MAX}\sin\omega t$ $\quad V = V_{MAX}\sin\omega t$

$I_{MAX} = \sqrt{2}\,I_{rms}$ $\quad V_{MAX} = \sqrt{2}\,V_{rms}$ $\quad X_C = \frac{1}{\omega C}$ $\quad X_L = \omega L$ $\quad V = IZ$ $\quad \omega = 2\pi f$ $\quad f_O = \frac{1}{2\pi\sqrt{LC}}$